The Commonwealth Forestry Review

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Forest Education

How appropriate is to-day’s education for the next generation of Forest Managers? The traditional University course concentrated upon the range of knowledge required to understand how trees and forests could be established, protected, tended and utilised. The forester schools gave greater priority to the skills needed to implement management decisions.

A manager needs to be able to assemble appropriate facts, appreciate what alternatives exist, assess the impact of each of these and select that which best serves the welfare of the area under responsibility. Satisfactory implementation of the policy will require the marshalling of materials and the co-operation of those who will service and be influenced by the decision.

A forester needs background knowledge of botany, agricultural chemistry, silviculture, forest pathology, forest entomology, forest engineering, management, harvesting, utilisation and marketing. It is hard for academic staff to keep up to date with the last three, if they do have expertise in these fields, they might be more lucratively employed in industry. Other subjects which should be covered include forest nurseries and propagation, site preparation for planting and subsequent establishment; the notes on chemical treatments may well require annual revision. There is also the question of landscape, recreation and the use of forests to protect water catchments and the environment.

Members of the Association are fortunate in being able to read English. Those for whom English is a second language have had the benefit of the mental stimulation which the learning necessitated and the associated development of intuitive powers which can enhance personal relationships. At least one second language will broaden the personality. There are options on whether it should be German or Russian to assist reading the literature, or Spanish, Portugese or Arabic to help relay forestry expertise or French and Italian for those who wish to retire to Switzerland after working for FAO. It is significant that Steve Kaufmann of MacMillan Bloedel who has just increased his responsibility for development policies around the rim of the Pacific is fluent in Japanese and Chinese.

In addition to the academic qualifications, no foresters should be released onto the labour market unless they can drive a car, use a power saw, programme a computer, address and maintain the interest of an audience for 20 minutes, navigate successfully on foot through 20 miles of broken terrain and be able to sell sawdust to the Chief Conservator. Accountants and retired service personnel have their contributions to make to the upper echelons of forestry business but the forester should have the potential to rise right through the hierarchy and be in a position to ensure that the important decisions are sound.

Greetings

We appreciated receiving cards at Christmas from Bangladesh, Canada, China, Guyana, Mauritius, Oxford, Scotland, UK Forest Research, USA, Yugoslavia and Zambia. Our visitors during the past year came from Australia, Canada, Ghana, Honduras, India, Indonesia, Nigeria, Oman, the USA and Yemen. The Common-
wealth Forestry Institute building also houses the Unit of Tropical Silviculture, the Commonwealth Forestry Bureau, the teaching and research side of the Institute as well as the Association. There are few places in the forestry world which do not receive some contact each year with staff making or reciprocating visits.

**Twelfth Commonwealth Forestry Conference**

The conference will discuss what needs to be done to secure the many and diverse social, economic and environmental benefits of forestry by well planned investment, using available land, labour, skills and scientific knowledge. The venue is Victoria, Vancouver Island, the dates, 8 September to 22 September, 1985. A pre-conference tour will visit forests and timber installations along a route starting from Montreal, travelling westwards, north of the Great Lakes with six overnight stops (2 – 7 September). A post-conference tour of southern Vancouver Island has been arranged to show integrated forest management in coastal British Columbia. There will be space for only a limited number of people on these tours; places being allocated to those who register earliest.

**Financial Assistance**

The Canadian International Development Agency (CIDA) offers support to many Commonwealth countries. Countries which have a CIDA project may find that funds can be made available to assist individuals to participate in the above conference.

The Commonwealth Foundation has approved in principle a grant of approximately £16,000 to assist a small number, approximately 12 delegates, to attend the above conference from developing countries. Grant aid will be limited to 75% of the economy class return air fare. A similar opportunity has been offered to the Association’s Secretary.

**Annual General Meeting**

A two day programme has been arranged for the 18 April and 19 April, 1985. The meetings will be south of Edinburgh. The A G M before lunch on Thursday the 18 April will follow a combined meeting of the Executive and Governing Council. This will be at Bush House, the Edinburgh Centre of Rural Economy at Penicuik. The afternoon will be spent on the same estate as guests of the Institute of Terrestrial Ecology. Whilst the Institute is much concerned with atmospheric pollution, we shall see an outline of work on three other aspects; the selection and propagation of elite clones for forest planting in West and Central Africa with indigenous broad leaves, the identification and selection of form characteristics and frost tolerance in trees suitable for the U K and the exploitation of mycorrizal fungi to improve early establishment, including a discussion on mycorrhizal successions. An Association Dinner will be held in the evening at the Cringletie House Hotel, two miles north of Peebles on the A703, set back off the Edinburgh road.

Friday 19 April will start once again at the Bush Estate as guests of the Forestry Commission Northern Research Station. It will be possible to see some of the vegetative propagation work with both pines and spruces. The Annual Address, before lunch, will be given by Roger Bradley who will highlight the Scottish prospects for the timber industry, including both for those that grow the trees and those that
utilise the timber. After lunch, our President has kindly invited us to visit his woods at Dalkeith, which include some particularly fine broadleaves. His Grace has offered us refreshment in Dalkeith House at the conclusion of the meeting.

Summer Meeting

The members of the Association have been invited by Mr. N.G. Halsey ARICS, Chairman of the Home Counties Division of the Royal Forestry Society, EWNI, to join the RFS meeting at Gaddesden Estate Office, The Golden Parsonage, Hemel Hempstead – just south of Luton – at 10.30 a.m. on Monday 3 June, 1985. Those intending to take part are asked to contact the CFA Secretary.

Autumn Meeting

Several members will be speaking during the 12th. Commonwealth Forestry Conference at Victoria on Vancouver Island. The programme mentions a meeting of the Commonwealth Forestry Association on the evening of Wednesday the 18 September which will be at the Conference Centre. The theme of the Conference on the 19 September will be Commonwealth Co-operation with an opportunity for the Secretary to address the Conference as one of the morning’s speakers. It is intended that a reception will be hosted by the Association later that evening at the Oak Bay Beach Hotel.

Commonwealth Professional Associations: Awards for Innovation

The Guinness Awards for Scientific Achievement and the Commonwealth Foundation have kindly sponsored the awards. There will be two awards for 1985 worth £2,000 each. Applicants will be Commonwealth Nationals whose innovative activities have contributed to sustainable development in a third world Commonwealth country. The activities to be covered by the 1985 awards should come under the heading of Technology or Communications. Members who consider that they can demonstrate that their ideas are already bearing fruit should forward the details to the Association at the CFI, Oxford by 1 November, 1985. We shall select the two most appropriate and forward these to the adjudicators by 1 December, 1985. Who is working on a micro nutrient impregnated, blue green algae planting pad to assist tree planting in arid areas? Photographs of desert reclamation should enhance the applicant’s chances. Have we anyone identifying underground water sources from satellite information?

Commonwealth Foundation Fellowship Scheme

The September, 1984 issue of the Review mentioned that the Association had the opportunity of submitting the names of two candidates for the 1985 Fellowship. Although this gave short notice, we did submit names from Bangladesh and Australia. Our commiseration with the former and congratulations to the latter. A.N. Cannon from Tasmania will be coming to London in April, 1985. These Fellowships are worth about £3,000 for travel and subsistence. We shall be seeking names for 1986, these should be with us 20 November, 1985 and can be nationals from Barbados, Brunei and Ghana; the subsequent year will be Belize, Dominica and Kiribati.
Commonwealth Fire Fighting

The Commonwealth Section of the International Association of Fire Chiefs was established in London in 1980. Kenya was the venue of their first conference and training programme. The Royal Air Force transported some of the equipment and personnel, the officers gave up their annual leave to take part and other assistance came from British Services Overseas and manufacturers of equipment. The training team visited local fire services and all major forestry stations. Members, elsewhere in the Commonwealth, who would like further information can contact the President of the Commonwealth Fire Officers, Kenneth Taylor, at 14 Kitley Gardens, Upper Norwood, London SE 19 2RY, UK.

Schlich Medal

The Schlich Memorial Fund was raised by donations from Sir William’s friends in education, forest management and the Timber Trade. In 1949/50, the Trustees allocated a sum to the Commonwealth Forestry Institute to provide an annual prize in recognition of the person making the most profit from the Oxford Forest Officer’s Course. At the close of the Specialist Forestry Course Programme, the 1984 award was made to Abhijit Ghose.

Forestry at Oxford

The Departments of Agriculture, Botany and Forestry at Oxford University will be amalgamated into the Department of Plant Sciences. The Commonwealth Forestry Institute will be renamed the Oxford Forestry Institute to denote its closer integration and greater academic recognition by the University authorities and emphasising that its activities now embrace all countries. Nevertheless, the Institute will continue to give priority to Commonwealth members in teaching, research, information and assistance. The acting Head of the Department of Forestry, Dr. J. Burley, has been appointed Director-Designate of the Oxford Forestry Institute which will come into being on 1 October, 1985.

IUFRO

The International Union of Forestry Research Organisations was founded between 1890–92. It is a non governmental, voluntary union of scientists with a membership of about 8,000. The XVIIIth IUFRO World Congress will take place between the 7 and 25 September, 1986 at Ljubljana, Yugoslavia. There will be 19 post Congress tours visiting various aspects of Yugoslavian forestry. Further details may be obtained from the IUFRO President, Dušan Mlinšek, Cankarjev Dom Congress and Cultural Centre, Trg Revolucije 2, 61000 Ljubljana, Yugoslavia.

The range of forest interests is identified under six IUFRO divisions:

A symposium on Whole Plant Physiology will be held between 6 – 11 October, 1985 at Knoxville, Tennessee, USA. Authors who wish to contribute are asked to forward the abstract of their proposed paper to Dr. D.J. Luxmoore, Environmental Science Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831 USA by 15 May, 1985.

Tom Gill Essay Competition

The theme for the 1984 competition was the subjects being discussed in the 12th Commonwealth Forestry Conference, “Investment in Forestry – the Needs and Opportunities.” The winning essay by Norman Weiss was ‘Forestry Investment. “Should I do a planting Scheme?” The Case for Lowland Broadleaves.’ Several essays were in contention but Mr. Weiss won by a mycorrhiza. He will receive a cheque for £150 and the Association’s Tom Gill Medal.

IX World Forestry Congress

Mexico City is the venue for the IXth Congress. The dates are July 1–10, 1985. Further details may be obtained from the Executive Co-ordinator, Ing. Jesus Veruette Fuentes, Progreso, 5, Edificio 2, Mexico, D.F. 04110, Mexico.

The theme is “Forestry Resources in the Integral Development of Society.” This covers – “the most important aspects of forestry activity in the world as well as regional and country scale. Thus, aspects of production, industrialisation, the rational use of forest lands, the interaction of resources with the environment and the production of foodstuff. Also covered will be aspects of law and institutions, the contribution of temperate and tropical forests and arid zones to vegetation energy production.”

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Ghana Timber Marketing Board

The Ghana International Furniture and Woodworking Industry Exhibition is to be held in Accra between the 6 and 15 April, 1985. The organisers of GIFEX ’85 visited European centres to encourage support and participation in the exhibition. The Trade Commissioner, Mr. Isaac Dakwa of the Ghana High Commission is seen greeting Mike Visram, the Managing Director of Forest and Sawmill Equipments (Engineers) Ltd. On the left of the photograph is the London Manager of the Ghana Timber Marketing Board.
Protective Clothing

Many countries have introduced health and safety instructions. Some are for general guidance, but others may be mandatory. Power saws now play an integral role in felling operations. It is the reporting and interpretation of accidents which has led to modifications. These include a cut out following 'kick back,' a reduction in vibration and a warning of the handle to decrease the risk of 'white finger', a reduction in exhaust noise and an additional protection for the ears with muff, a protection for the head with a 'hard hat', the eyes—with a shield, the feet with reinforced toe caps and the legs with tear resistant trousers. This protection can itself cause problems by decreasing ones awareness of surroundings. The Russians have a hard hat with built in alarm which is activated when others are felling in the immediate vicinity. Early days with chemical sprays left chances of contamination both inside and outside the body. Protective suits, boots and masks modify the risks, but it is disturbing to read that one of the filtering substances used in war time gas masks was blue asbestos. In some countries the employer may be obliged to provide protective clothing but the field staff may still avoid its use. An abstract, (FA Vol. 44, No 1, 1975) suggests that conservationists may be lobbying the Health and Safety powers, the article in *Medical Parasitology and Parasitic Diseases* is 'A suit for simultaneous mechanical protection of the human body
ixodid ticks and gnats'. Gone are the days when the temperate forester, with his tweed hat, could pass as the laird or the game keeper, now it is an orange hard hat, complete with flashing light and a tape which proclaims, in English and German, that the owner is not a moose.

Erratum

In Vol 63(3), No 196, September, 1984 on page 193 in the article on ‘Sampling with Partial Replacement- A literature Review,’ we published “The standard error of the difference is the sum of the standard errors . . .”. This should have read –“The standard error of the difference is the square root of the sum of the squares of the standard errors . . .” Our apologies to the authors and to members.
Dear Sir,
A group of Edinburgh University forestry graduates now working in British Columbia are planning an informal get-together in Victoria to be held on Tuesday, 10th September, 1985 in conjunction with the forthcoming Commonwealth Forestry Conference.

We plan to meet in the Holyrood House (where else?) for a buffet supper (cost $15.00 drinks extra). There will be no speeches or other ceremonies. All Edinburgh forestry graduates, of any age class, will be welcome. Those who contemplate attending should contact either myself or Dr. Paul Barker, Research Branch, Ministry of Forests, 1450 Government Street, Victoria, B.C. V8W 3E7.

Can we, please, ask you to make mention of this in the next Review.

Yours sincerely,

R.M. Strang
Executive Director
Forest Research Council of British Columbia.
NEWS OF MEMBERS

Shri C. L. Bhatia, has retired from the post of Inspector General of Forests for the Indian Forest Service. He joined the U.P. Forest Department in 1949. His visits overseas took him to Japan, Hungary and Sumatra. In Rome, he advised FAO on the forest resources in Asia and Pacific region. His successor is Shri L. H. A. Rego who was previously Chief Conservator of Forests in Maharashtra. Shri Rego was conferred by the Pope with the Pro Ecclesia Pontifice gold medal for his service to the Church in India.

Dr. J. Burley, currently acting Head of the Department of Forestry at Oxford, has been appointed Director- Designate of the Oxford Forestry Institute.

Jack Gittins, of ACIL Australia PTY Ltd., is spending six weeks assisting with the Songkhla Lakes study in Southern Thailand. The project is funded by the Asian Development Bank. He recently joined several other ACIL consultants in preparing a report for the Victorian Government on the policies and initiatives which would foster the future of the State’s Timber and Forest Products Industries.

George Holmes, CB, Director General of the British Forestry Commission, has been appointed as Honorary Professor to the Department of Forestry at the University of Aberdeen. He graduated from UCNW Bangor with a First Class Honours in Botany; the University of Wales has awarded him with the Honorary Degree of Doctor of Science (DSc).

Peter McKelvey, retiring Professor at the University of Canterbury, New Zealand, has been honoured with the Order of the British Empire. Professor Everett Ellis is also retiring from the same Department of Forestry; the faculty, which was founded in 1968, will be appointing only one incoming Professor.

Robin Levington is retiring from the FAO where he was Senior Forestry Officer (Plantations and Protection) to 3/85 West Esplanade, Manly, NSW, 2095, Australia. He will also be relinquishing his duties as Secretary to the International Poplar Commission.

OBITUARY

Angus Pearson MacBean, B.Sc.F., R.P.F., life member of the Association of British Columbia Foresters died peacefully on October 29th at 77 years of age. Funeral services were held in St. Catherines Anglican Church, Port Coquitlam, B.C.

The forestry profession has lost a man whose integrity and sense of humour matched his professional skills.

Angus was born and raised in Medicine Hat, Alberta. After graduating in forestry from the University of Toronto in 1930 he worked for the Ontario Department of Lands and Forests and for Candian Splint and Lumber Co. before moving west in 1937 to join the B.C. Forest Service to work on silvicultural research. He participated in the well-known “Ladysmith Experiment” which preceded a new era in pulpwood utilization in Coastal B.C.

In 1945 Angus joined the Victoria Lumber Company which later became a part of the present company – MacMillan Bloedel Limited.

He became Chief Forester of MacMillan Bloedel Limited in 1950 and later Group General Manager. In this capacity he contributed very significantly to acquisition of the company’s timber resources, negotiation of Forest Management Licence Agree-
ments and in development of forest management plans and implementation of the operational programs. He could be considered a leader in industrial forest management in North America and was greatly admired for his vision concerning our industry.

In his later career Angus was involved in developments across Canada and in Australia, Malaysia, Mexico and Brazil. Angus served his profession well and many foresters who are still active can attest to the friendship, wise counsel and training which they received from him.

His achievements were recognized by his peers in the form of lifetime achievement awards from the Canadian Institute of Forestry and the Western Forestry and Conservation Association.

Those of us who share fond memories of our association with Angus will join in condolences to his loving wife Dorothea, his children Don and Elizabeth and their families and to his brother Don.

Grant L. Ainscough, R.P.F.

MEMBERSHIP

Life (transferred from Ordinary Membership)
LESLEE, A. J. PO Box 191 Apollo Bay, Vic 3233 Australia

New Members
Life
ROSS, M. S. Dr. c/o CFI South Parks Road, Oxford OX1 3RB

Affiliated
CONSERVATION COMMISSION OF NT. PO Box 38496, Winnellie NT 5789 Australia
INTERFOREST (UK) Ltd, Forestry Manager, 63 Lincoln's Inn Fields, London WC2A 3JX
SABAH FOREST INDUSTRY Sdn Bhd PO Box 4 Blk.1 Likas Complex, Kota Kinalbu, Sabah, Malaysia

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ARMSTRONG, G. D. EMI Forestry Project, PO Box Embu, Kenya
BRISTOW, S. C., Forestry Department, Ed Damer, Nile Province Sudan
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CORNELIUS, J., Whitebeam Cottage, Trerhynll, Conbridge S. Glam CF7 7TN (from Associate Member)
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HANCH, A. D., SRDA Project Centre, Box 14, Nhlangano, Swaziland
HENDERSON-HOWAT, D. B., Shiselweni Forestry Co. Ltd., PO Box 98 Nhlangano, Swaziland
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POWELL, P. I. 13 Brighton Road, Reading Berks RG6 1PS
SNIEZKO, R. A., FRC POB HG 595 Highlands, Harare, Zimbabwe
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WRIGHT, J. A. c/o CFI, South Parks Road, Oxford OX1 3RB

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FORTHCOMING INTERNATIONAL DATES

Ref: MR. N.Y. Ossei Gerning, Manager (London Office)
Ghana Timber Marketing Board, 102 Park Street, London WY 3RJ. Tel: 01 493 4901/4836 and/or The Organisers, GIFEX ‘85 at PO Box 32 Trade Fair Site, Accra

18/4/85– 19/4/85 SCOTLAND, Commonwealth Forestry Association AGM at BUSH followed by visit to Dalkeith Estate.
Ref: M. T. Rogers, c/o CFI South Parks Road, OXFORD.

Ref: The Symposium Secretariat S.115, CSIR, PO Box 395, Pretoria, 0001 South Africa.

Ref: Caesar Kelberg, Wildlife Research Institute, College of Agriculture, Campus Bar 218 Kingsville 78363 Texas

Ref: G. V. Wellburn, FERIC, Suite 201—2112 West Broadway, Vancouver BC V6K 2C8

20/5/85– 24/5/85 HOBART, Tasmania. ‘Australia and New Zealand Inst. of Foresters.’
Ref: Evan Rolley FC Tasmania, Surrey House, 199 Macquarie St., Hobart, Tasmania 7000.

21/5/85– 23/5/85 USA—University of Southern Mississippi—18th Southern Forest Tree Improvement Conference.
Ref: Dr. M. M. Griggs or Dr. R. C. Schmdtling, USFS Southern Forest Experiment Station, PO Box 2008 GMF, Gulfport, MS 39505

Ref: P. Harstela, Finnish Forest Research Institute, SF-77600 Suonenjoki, Finland

3/6/85– 8/6/85 VIENNA, Austria, ‘Symposium on seed problems under stressful conditions’
Ref: J. Nather, Federal Forest Research, A-1131 Vienna, Austria.


1/7/85– 14/7/85 MEXICO CITY, ‘9th World Forestry Congress.’
Ref: L. J. Castanos Martinez, IX Congreso Forestal Mundial, Netzahualcoytl No. 198 1er Piso, Mexico DF/CP 06080

held in co-operation with Auburn Univ., Southern Forest Nursery Management and MacMillian Bloedel Inc.
Ref: R. E. Mitchell, Department of Forestry, Auburn University, AL36849-4201

8/85–9/85 CANADA. Symposium on ‘Silvicultural Equipment Development Problems, Site Preparation, Equipment Evaluation Techniques and Soil Interactions’.
Ref: L. F. Riley, Great Lakes Forest Research Centre CFS. 1219 Queen St. East, PO Box 490 Sault Ste. Marie, Ontario, P6A 5M7

8/85–22/85 VANCOUVER ISLAND, 12th Commonwealth Forestry Conference. ‘Investment in Forestry—Needs and Opportunities’.
Ref: Forestry Commission, 231 Corstorphine Road, Edinburgh, EH12 7AT, UK.

9/85 MOSCOW, USSR. ‘Thinning problems’ (IUFRO).
Ref: Prof. R. Plochmann, Forstwiss. Universitat Munchen, Amalien st. 52, D-8000 Munich 40, German Federal Republic.

9/85–12/85 UK Silsoe. Symposium on Ergonomics—‘Noise and Vibration in Agriculture and Forestry’ (jointly with IAAMRH and CIGR)
Ref: F. J. Staudt, Dept of Forest Techniques and Forest Products, PO Box 342, NL 6700 Wageningen, Netherlands

Ref: PITA. 3 Plough Place, Fetter Lane, London EC4A 1AL

Ref: Muskoka Conference ’85, 112 Clair Ave. West., Suite 303 Toronto, Ontario, Canada M4V 2YS


15/11/85–17/11/85 CANADA—Canada Wood ’85, Palais des Congres, Montreal, Quebec

27/11/85–30/11/85 KUALA LUMPUR, Malaysia. ‘Wood Malaysia ’85. (Trade Fair.)
Ref: E. Heng. ITF PTE Ltd., 1 Maritime Square No. 12-03, World Trade Centre, Singapore 0409.


31/8/86–6/9/86 AUSTRALIA, Queensland. All Australian Timber Congress
7/9/86–25/9/86 LJUBLJANA, Yugoslavia. ‘Forestry Science Serving Society.’ (IUFRO World Congress)

Ref: R. L. Newman, Australian Forest Development Institute, PO Box 515 Launceston, Tasmania 7250
CHILE

The Legislative Decree No 701 encourages private planting and ensures reforestation. Up to 75% of the establishment costs are re-imbursed. The annual planting rate before 1981 has been about 20,000 ha, the 1982 figures were 62,265 ha of new planting and 5,751 ha of reforestation. The Director of Forest Industries, Patricia Valenzuela, informed Chile Forest News that the existing 1 M ha of plantations, with a continued annual afforestation programme of at least 50,000 ha, would raise the available standing timber from the 8 M m³ of 1980/82 to 16 M m³ by 1989 and 24 M m³ by 1998. By the year 2000, the annual production would be 10 M m³ of sawn timber, 6 M m³ of logs and 2 M T of pulp. The additional investment required to utilise this resource of timber, mainly Pinus radiata, would be US $ 3,500 M.

Argentina has been a major destination for forest exports from Chile, but that country is becoming more self sufficient in timber and other markets are increasing in importance. In 1983, Argentina took about 0.2 M m³ of sawn radiata, Korea, 0.5 M m³ of saw logs, China imported 74,200 T of unbleached pulp, and 0.25 M m³ of saw logs, the German Federal Republic, 39,600 T of unbleached pulp, the UK increased bleached wood pulp purchase from US $ 1.7 M to US $ 10.5 M and other destinations included Indonesia, the USA, Oman, Singapore, Thailand, New Zealand and Japan. The increases in Chile's radiata exports to Japan are being mirrored by declining sales of Japan's purchases from New Zealand.

The TALCA factory produces 14,000 M matches a year and has managed to reduce its poplar rotation from 18 to 14 years. TEMSA produces 120 M ice cream sticks a month and has captured 40% of the US market - this item was mainly responsible for the US $ 125,868, 1983 export to South Africa. The LAJA company owns 150,000 ha of plantations and is spending US $ 40 M to increase current annual maximum of 310,000 T long fibred pulp. Forest waste will be able to replace 25,000 T of LAJA'S fuel oil with an annual saving of US $ 5.8 M.

CHINA

Dr. I. Bevege and Dr. R. Curtin in the December 83 issue of the Forest and Timber of New South Wales report upon the development of relationships between Chinese and Australian foresters. The sub-tropical area of Guangxi has had a large scale eucalypt planting programme since 1965. Two natives of Queensland, E.citriodora and E. exserta are planted on highly weathered lateritic soils with gentle topography. Seedlings, at the 4–6 leaf stage, are transplanted into locally prepared soil bricks (8cm² × 10cm). They are ready for the forest after a further two months, being planted at 4,000 / ha, thinned twice, late in the fourth year and early in the eighth and felled in the tenth year. The produce, which includes small saw logs, is used in the mines, for light constructional work and for fuel. Eucalyptus oil is distilled from the leaves. Under the auspices of the Australian Development Assistance Bureau in April/May 1981, the Queensland Department of Forestry has arranged for three of their foresters to work in Nanning and for Chinese foresters to study natural forests and plantations in New South Wales and Queensland.

Some 28 M ha have been planted since 1949; this has increased the forest cover from 8.6% to 12.7%. Wood production has risen from 5 M m³ in 1949 to 54 M m³ in 1980.
The current objective is 4 M ha a year, bringing the forest cover up to 20% by the year 2000.

A report on China’s “great green wall” outlines a project commenced in 1978 to halt the expansion of the northern deserts which have extended over an additional 6 M ha during the last 30 years. A belt of trees, 5000 km long by up to 12km wide, is being planted to the north and west of the traditional Great Wall. The report by Allan Humphries in the same publication of Forest and Timber mentions that the population of China exceeds 1,000 M and that each able bodied person between 10 and 60 is obliged to plant at least three trees a year.

GHANA

Following the banning of log exports in 1979, to encourage the increase in local timber conversion and subsequent boost in exports having value added, the hauliers and millers encountered government restrictions which hampered the import of vital machinery spare parts. The whole timber industry went into a state of delcine. The Ghana Ministry of Lands and Natural Resources is now making vigorous attempts to re-vitalise the timber industry. The Ghana Timber Marketing Board is being replaced by the Timber Export Development Board and will be divested of all their assest in subsidiary companies. The timber based industries will be encouraged with finance of approximately US $ 40 M made available by the government and World Bank, backed by World Bank and IMF loans and standby credit of $ 600 M and a further $ 150 M in aid from Western Europe. The Swedish consultants ‘Silviconsult Ltd.’ are already helping with technical assistance. The timber resources are already adequate to meet domestic requirements for the next 45 years and allow surplus for export. In addition, the long established replanting programme promises that timber should continue as an important raw material and that trees will make their contribution towards a healthy environment.

HUNGARY

The ‘Scientific Publications of Forestry and Timber Industry’, Erdészeti és Faipari, 1982 vol.1 and 2, offer summaries in Russian, English and German as well as Hungarian. The titles give some insight into the relative importance of various tree species and factors which can influence their performance. Volume 1 mentions oak, robinia, fungi, Gipsy moth, birds and forest mathematics, Volume 2 has 14 articles, with oak and robinia again prominent with poplar and pine, other subjects include timber machining, use of timber in construction, land restoration, conservation and tissue culture. The latter by, Katalin Tóth, uses 37 references from 12 different countries, 8 from Eastern Europe and six each from New Zealand, Canada and France.

The use of scientific names can assist understanding; the paper by Faragó appears in the Table of Contents as: ‘The role of the soil in the range and incubation of bastards (Otis tarda L. 1758) in Hungary.’ Dr. Elemér Somkuti’s paper on the valuation of the forest estate gives the area of oak forest in 1980 as 340,000 ha, 23.14% of the total forest. 27% of the standing timber. The Russian summary specifically mentions Quercus cerris but Dr. J. Koloszár is referring to Q. robur, the merits of early and late flushing strains and Dr. Zoltán helps further by giving various oaks, their percentages and the authority for their classification – Q.robur L., Q.cerris Oerst., Q. rubra L., Q.petreae (Matt.) Lieb. and Q.pubescens Willd.
Dr. Molnár concentrates upon *Robinia pseudoacacia* L. which ‘is the most widespread quickly growing species of tree in Hungary.’ The article compares the timber characteristics of coppice and seedling material.

The survey of polypores (Polyporaceae) in Hungary by Dr. Zoltán mentions 112 fungi, including both pathogenic and those which are just saprophytic. The order in which 17 broadleaved species is taken, appears to be in decreasing significance with a combined oak percentage of 27% (*Q. robur* 13.4%, *Q. pubescens* 1%, *Q. cerris* L. 13%), False acacia (*Robinia pseudoacacia* L.) 18%, beech (*Fagus silvatica* L.) 7%, Hornbeam (*Carpinus betulus* L.) 7%, Ash (*Fraxinus excelsior* L. and *F. angustifolia* Vahl.) 2%, Alder (*Alnus glutinosa* and *A. incana*) 2% and poplar (*Populus* spp.) 11%. It is encouraging to recognise the Hungarian for Sweet Chestnut (*Castanea sativa* Mill) as Gesztenye and ‘acacia’ as akác. beech as bukk, but as a warning against making assumptions, Szilek is not *Salix* but *Ulmus*, willow being fűzek. The order and percentages for the conifers are as follows: - *Pinus silvestris* 9%, *Pinus nigra* Arn 4%, *Picea abies* Karst 1%, *Larix decidua* Mill 0.1% with both *Abies alba* and *Juniperus communis* being mentioned. The fungal species which feature most frequently with the broadleaves include *Fomes fomentarius*, *Polyporus squamosa*, species of *Phellinus* - *P. torulosus* on *Quercus*, *P. robustus* on *Robinia* and *Carpinus*, *P. igniarius* on *Salix* and *Alnus*, species of *Ganoderma* – *G. resinaceum* on *Quercus*, *G. adspersum* on *Robinia* and *Fraxinus*, *G. applanatum* on *Fagus*. The fungi causing problems with the conifers include *Phaeolus schweinitzii*, *Phellinus hartigii* and *Heterobasidion annosum*. The latter is also mentioned on *Alnus* which will influence the future management of some UK stands where the editor has been dutifully treating pine stumps with a prophylactic against fomes, but has ignored the stumps of alder in the mixture.

Dr. Vancsura’s paper on the reclamation of quarry spoil in the GDR (East Germany) recommends the use of nitrogen fixing plants (*Lupinus, Hippophae* and *Amorpha*) followed with poplar.

**ITALY**

The *Annali della Facoltà di Scienza Agrarie*, University of Torino Vol XII covers the years 1979/80, 80/81 and 81/82. Most of the papers would have more interest for those involved with Mediterranean farming and wine production. A comparison between the costs of some forest operations carried out either manually or mechanically, showed the latter to be 40% cheaper. Trials to improve the proportion of poplar bark which animals could digest showed that a 4.5% solution of Sodium hydroxide raised the percentage from 21.6% for the control to 29.4%, a stronger 6% solution only raised the percentage to 28.3%. The species used in spacing trials included *Pinus, Eucalyptus*, and *Populus* with desirable spacing on slopes being 3 x 2.5 m, there is also mention of *Larix* and hardwood coppice of *Betulus* and *Castanea*. A plant sucking aphid which is causing damage to spruce (*Picea*) in the Aosta Valley near Turin is an hemiptera pseudococcidae, *Paroudablis piceae* Low.

**KALIMANTAN**

The *New Scientist* 22.9.84 draws attention to what is claimed to be the world’s largest forest fire which burned from September ’82 to July ’83 in E. Kalimantan, the Indonesian Sector of what was Borneo. Smoke haze closed the airport 250 km away, across the Java Strait of Surabaya, it also caused interference at Singapore 450 km away. The area damaged included 800,000 ha of primary forest and 550,000 of peat
swamp, other cut over forest bringing the total to 36,000 k m². As with the Australian fires, the surface heating counteracted the long standing anticyclonic period of descending air mass which had contributed to the drought which preceeded the fires. Heavy and continuous rain gave subsequent conditions of almost permanent monsoon. The Association’s Honorary Secretary in New Zealand, Neill Cooper mentions in the January ‘85 issue of the Quarterly Journal of Forestry, that he had flown over part of the 3 M ha damaged by the fires. During the two hours’ flight he noticed few areas of burnt plantation but records that the sheer magnitude of coping with the devestated area was awesome.

NEPAL

The United Mission to Nepal (UMN) is a non-profit making organisation funded by 32 different missions from some 16 countries. A Rural Development Centre has been established in Pokhara, a city some 200 km west of Kathmandu. The Centre acts as a support agency to 8 UMN rural development projects, one of which is associated with forestry. Further details may be obtained from UMN, Rural Development Centre, Chipledgunga, Mahendrapul, Pokhara, Nepal.

NORWAY

Reports from the Norwegian Forest Research Institute published in 1983 and 1984 are in English with Norwegian summaries. Bulletin 38.7 highlights the problems encountered from fungi attacking Norway spruce (*Picea abies*) in cold store. Fungi from 69 taxa were isolated from transplants in store, at least 10 of which grew in temperatures between — 3°C and 0°C, many others, although less frequent, could also grow at temperatures of 0°C and lower. The trees suffered both needle and stem damage. Standard treatment with ‘quintozene’ (pentachlorinitrobenzene) gave some protection when used as a dip, but moulds continue to develop if the plants were merely sprayed. A typical nursery fungus causing winter damage is *Herpotrichia juniperi*, other families include *Rhizoctonia* spp, *Fusarium* spp, *Cylindcarpon* spp, *Ceratobasidium* sp, *Septonema* sp, and 28 species of *Botrytis*.

Each bulletin is devoted to a specific article. The following points give some insight into the subjects which are considered pertinent:-

38. 8 Birch stand criteria – the proportion of trees over 11 cm diameter, the minimum economic size.
38. 9 Composting of bark sprayed with lindane – little alteration to the chemical in first 100 days, but rapid reduction after 150 days. Composting should be for at least 7 to 9 months.
38.10 Monitoring reduced transpiration stream velocity in Norway spruce attacked by bark beetles – *Ips typographus* introducing blue stain fungi which aggrevate the tree’s stress.
38.11 Effect of temperature on annual shoot growth of *Picea abies* at Troms 69°N, 19°30’ E – correlation with June and August but little with September.
38.12 Tree species and fertilization programme on peatland in Middle and North Norway – Dr. F. H. Braekke reports results with *Pinus contorta* and *Picea mariana* performing better than *Picea abies* and *Pinus silvestris*. The pines perform better than the spruces on nutrient poor peatlands but suffer more moose damage. Maps show the locations of desirable provenances of Sitka
(Picea sitcheasis), Lutz spruce (Picea x lutzi Little), White spruce (P. glauca), Black Spruce (P. mariana) and Lodgepole (Pinus contorta).

38.13 Improvement of elderly annual ring measure equipment with an APPLE 11 micro computer – ADDO equipment, designed in 1949, installed in 1960, improved with a magnetic ruler to measure linear movement of 0.01cm and in 1974, improved to read 0.001cm, this is still in use linked with an APPLE 11 micro computer. Subsequent calculations can be made with IBM computer.

38.14 Sampling density of natural regeneration – Pinus silvestris, Picea abies, Betula verrucosa.

PORTUGAL

The Timber Trades Journal, 22 September, 1984, uses seven sources of information to offer an insight into the importance of forestry in Portugal. Forests occupy 33% of the land, 2.9 M ha out of a total of just under 8.9 M ha. Within the forests, the major species (44%) is maritime pine (Pinus pinaster) with oak (Quercus rotundifolia and Q.suber) covering 40% and eucalypts 7% (215,000 ha). The private sector, including nationalised companies, owns 73% of the maritime pine forest, with the 950,000 ha being distributed amongst approximately half a million individuals. There are some 1,200 sawmills, most of which produce under 30 m³ a day. During the six years from 1978 to 1983, a steady rise in log consumption from 3.4 M m³ to 4.8 M m³ has followed an increase in exports of sawn maritime pine from 637,000 m³ to 893,000 m³. Timber products represent 18% of the Portuguese export trade. The pallet industry takes 67.5% of the produce. An FAO/World Bank study in 1980/81 – The Portuguese Forest Plan – recommended an annual planting programme of 32,000 ha. There is sufficient uncultivated land and degraded agricultural land to provide an extra 2.3 M ha for establishment, of this 900,000 ha would be suitable for maritime pine. The pine is grown on a rotation of 50 years with a thinning for pulp at year 15 and for saw logs at years 25 and 35. (The yields quoted in the article have the wrong units – 15,000 m³/ha, 40,000 m³/ha and 100,000 m³/ha but no doubt represent the comparative volumes available at years 25, 35 and 50.) Fire is a major problem, some 272,000 ha of forest being destroyed between 1975 and the early 1980s.

ST. HELENA

The following report from the forestry advisor, A. R. Barlow, gives outlines of recent developments on the island.

The steep central highland area formerly covered with Phorium tenax has been strip cleared along the contour and over 230 ha has been planted with Pinus, Eucalyptus, Acacia and Podocarpus species. Healthy and vigorous stands have been established but the effects of drought and grass competition required considerable beating up. Sample plots in these plantations are showing mean annual increments of 30 to 35 m³/ha. A sawmill was commissioned in 1977; there is a ready market for building timber but much of the produce has been used as posts for stock fencing. Over 26,000 posts have been treated. A solar kiln assists with the seasoning. Firewood continues to be a very important forest produce especially as alternative fuels need to be imported. Protection planting is being carried out around the barren, dry, periphery of the island where erosion is threatening agricultural land. Species trials demonstrate the adverse effects of saline conditions but some endemic species may add to the aloe and acacias already in use.
The re-discovery in 1981 of the St Helena ebony, *Trochetiopsis erythoxylon* thought to have been extinct for over 150 years, has encouraged much greater interest in the local flora. One of the staff from Kew has been instrumental in propagating many of the endangered species. The World Wildlife Fund has provided finance for a mist unit helping to establish an arboretum.

Although the forestry programme and timber production may be small compared with other countries, the value for St. Helena, of the employment, import substitution and soil protection is highly significant.

**UGANDA**

The World Bank sent a project identification team to Uganda in December 1984, to investigate the need for rehabilitation of Forestry and the Forest Industries. During the Amin era and in particular since the 1979 liberation war, when the disruption and looting deprived the Forest Department of a large part of its tools and equipment, the Department has been unable to carry out much effective forest management. Funds for anything except the payment of staff salaries have been extremely short and even basic tools such as axes and hoes are in very short supply. Recovery has been slow to start but the appointment of Mr. P. K. Karani, a very experienced forester, as Chief Forest Officer, the receipt of small amounts of aid for forest inventories and assistance from CARE in starting some 140 nurseries will all offer a welcome nucleus for recovery. The prospect of aid from the EEC, the World Bank and others is good, but the time taken for funds to materialise is often as long as four years. Although natural forest reserves have suffered from encroachment and the depredations of pit-sawyers and charcoal burners, they are still substantially intact. Fuel and pole plantations around towns have suffered very badly and the demands for wood fuel are beginning to denude the countryside which was previously well stocked with native bush. The conifer plantations are intact (but under thinned) and now have large standing volumes of utilisable sawlog sized timber.

Aid is badly needed to re-equip the Department, rehabilitate the State owned forests and develop extension services for social forestry.

**UNITED KINGDOM**

The 1981 Forestry Act enabled funds to be realised from the sale of Forestry Commission assets. The initial figure was £40M by 1984, this was increased to £65M and then £82M. In reply to a Written Parliamentary Question, the Secretary of State for Scotland, Mr. George Younger, MP said that (by the autumn of 1984) some £56M had been raised and a further rationalisation of the Commission's estate could raise an additional £45M by the end of March 1989. The area sold by the end of March 1984 was over 16,500 ha, some 270 plantations, with another 32,800 ha awaiting signature. During the year, the Commission has purchased 2,782 ha, planted 8,382 ha of new land and restocked 6,753 ha. Grant aided private planting for the year up to 31 March 1984 was 19,740 ha compared with the previous year's figure of 15,629 ha. Much of the private planting (16,673 ha) was on bare land, the area planted with broad leaves under grant assistance was 1,711 ha. The map reference for one of the Commission's areas being offered for sale is a damp location, half way between the Isle of Man and the mainland.

Various committees have been established to assist the Forestry Research Coordination Committee. The Chairman of the one on Broadleaved Woodlands is
John Workman (National Trust) and the members being R. E. Crowther (F/C), Dr. O Rackham (Cambridge University), R. Venables (Timber Merchants: Stafford). One on ‘further aspects of Tree Physiology’ has Professor Cooper (Ex Welsh Plant Breeding Institute) as its spokesman. The members of the ‘Forestry and the Environment’ committee are Dr. F. C. Hummel (Ex Head of the Forestry Division in EEC), John Campbell (EFG), Dr. D. A. Langslow (NCC) and Dr. M. H. Unsworth (ITE Bush). Other Review Groups to be established during 1985 are ‘Integration of Forestry and Agriculture in the Uplands’ and ‘Biotic damage’ – by animals, insects, fungi and presumably bacteria. It is encouraging to see several of our members making a contribution towards National and International Forest Policy.

Contributions on any of the above subjects will be welcomed at Forest Research, Alice Holt, Wrecclesham, Farnham, Surrey.

USA

The Scott Paper Company is investing a further $300 M at Mobile, Alabama. Part of the investment will enable the energy requirements to be drawn from the burning of coal or biomass; this could make the plant 60% self sufficient in its energy consumption. The private planting programme in Alabama for the ’82/’83 season was over 130 M trees, the total private planting that year for the southern 13 states being 900 M. (Journal of Forestry, 4/84.)

USSR

The Institute of Chartered Foresters’ 1984 meeting on the ‘International Aspects of Forestry’ included a paper by L. R. Atkinson of Foy Morgan on ‘The Forests and Forest Industries of the USSR.’ The complete article is available with the proceedings of the meeting from 22, Walker St. Edinburgh.

The total forest area in the Soviet Union is 1,257.3 M ha, about 20% of the world’s forested land and the stocking of timber, 84,000 M m$^3$ represents about 25% of the world’s total wood resource and over 50% of the world’s conifers. The major species are larch (Larix) 40.6% pine (Pinus sylvestris) 17.4%, spruce (Picea) 11.9%, other conifers 8.3%, light hardwoods (Betulus and Populus) 16.9% and other broadleaves (Quercus, Fagus, Fraxinus) 4.8%. Collective farms and Ministries other than the State Forest Service administer 8% of the forest land, the State Committee for Forestry administers the other 92% (1,186 M ha). If lightly stocked land is excluded, productive forest covers 729.3 M ha but 62 M ha are still recovering from overcutting during the war and 124.4 M ha have considerations other than timber production as their main concern, these include protection forests for marginal land, water catchment and fish spawning grounds and a further 195 M ha are at present inaccessible for commercial exploitation.

The total annual increment is assessed at 924 M m$^3$ with a permissable cut of 670 M m$^3$ of which the amount felled in 1980 was 386 M m$^3$. The low increment figure of 1.4 m$^3$/ha/annum reflects in part the severe climatic conditions (rotation ages for pine being up to 150 years) but also the denser stocking of mature timber in the east. The effect of silviculture and drainage in the west, raised the local annual increment from 1.9 m$^3$/ha in 1966 to 2.14 m$^3$/ha in 1978. The area of the locality’s young and middle aged crops increased by 24.3 M ha with an associated felling of 6.8 M ha of mature timber.
Afforestation between 1961 and 1978 brought a further 42 M ha into the category of forested land. Over 1 M ha are naturally regenerated annually which with a similar area being planted brings the annual total to about 2.34 M ha. Some 9,000 nurseries use over 7,000 T of seed to produce 7,000 M seedlings of over 60 species. The species planted for commercial forestry are 50% pine and 28% spruce. The choice of species for the annual programme of 100,000 ha of planting in arid and semi-arid zones will be influenced more by the tree's chance of survival than by any potential timber utilization.

Forest products represent about 5% of the value of the country's industrial production. The percentages of conifer timber felled for industry range from 63% to 76% for various species, for the light hardwoods, 22% to 40% and for oak and beech about 60%, the respective percentages used for fuel are 14%–19%, 55–70% and about 33%. The major industrial category is sawn timber, the annual figure being between 115 M m$^3$ and 120 M m$^3$. Preparation of suitable material for export is limited to specific mills. In 1983 the UK imported 1.2 M m$^3$ which was 17% of the UK sawn softwood import. This 1.2 M m$^3$ was 70% pine (*Pinus sylvestris*) and 30% spruce (*Picea abies*). All but a fraction was of a quality and price higher than that of carcassing and case making – mainly imported from Canada and Scandinavia. The recent year's export of 6 M m$^3$ of saw logs to Japan was essentially larch (*Larix*) which dominates the eastern regions.
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THE PROVENANCE DEVELOPMENT OF PINUS KESIYA IN THE NORTHERN TERRITORY OF AUSTRALIA

By S. TOZER, R. ROBERTSON and M. W. HAINES*

SUMMARY

Intermittent small trial plantings of Pinus kesiya were made in the Northern Territory from 1962/63. Results are presented for one of these plantings, embracing 7 provenances and a Honduras Caribbean comparison, which reflects performance in this region. Standard procedures were used for assessment of 15 growth and form traits at age 9 years. Few notable differences are apparent between the P. kesiya provenances, but trait expression may have been modified under local climatic conditions. Although the growth of Pinus kesiya in this region has been relatively poor, the results may complement data from established international trials in defining the environmental limits for successful growth of this species in the tropics.

RESUME

Des essais à petite échelle de P. kesiya ont été établis à des intervalles irréguliers dans le Territoire du Nord depuis 1962/63. Les résultats présentés ici pour un de ces essais portent sur sept provenances et sur un pin caribbeen. Les mesures habituelles ont été effectuées pour 15 facteurs à 9 ans. Peu de différences se manifestent entre les provenances, à cause peut-être du climat local. La croissance était médiocre mais ces données pourront compléter celles qui proviennent d’essais plus connus en montrant les limites du milieu pour la croissance de cette espèce.

RESUMEN

Se plantaron parcelas experimentales pequeñas de Pinus kesiya en los años 1962/3. Se presentan los resultados de algunas de estas plantaciones que incluyen siete procedencias y un testigo de P. caribaea desde Honduras que representa el comportamiento promedio de la región.

Procedimientos normales fueron aplicados para la evaluación de 15 caracteres del crecimiento y de la forma a una edad de 9 años. No se ve diferencias notables entre las procedencias de P. kesiya aunque la expresión de los caracteres pudo haber sido modificada baja las condiciones climáticas locales.

Aunque el crecimiento de P. kesiya en esta región estaba relativamente mal, los resultados pueden aumentar los datos de ensayos internacionales ya establecidos para definir los límites del medio ambiente para el cultivo con éxito de esta especie en los trópicos.

Introduction

Pinus kesiya Royle ex Gordon has been one of many exotic species tested for plantation potential in the Northern Territory of Australia. Trials of this species commenced in 1962/63 but establishment deficiencies resulted in generally poor performance. Improved early growth in a subsequent block planting suggested the

* Forestry Unit, Conservation Commission of the Northern Territory, P.O. Box 38496, Winnellie, N.T. 5789, Australia.
need for a more detailed examination of the effect of seed source on growth under local conditions. The trial discussed in this paper (EP 476) was implemented for that purpose.

Materials and method
The location of the trial site is indicated in Figure 1.

The site is located on the low, central Melville Island plateau (altitude about 90 metres a.s.1.) and previously carried Eucalypt forest (E. miniata, E. tetrodonta and E., nesophila) to a height of around 25 metres. The area is generally flat and comprises sandy/gravelly red earths with good internal drainage.

Average annual rainfall is estimated to be around 1900 mm; the distribution being typically monsoonal with 75–80 percent of the precipitation occurring between December and March. The mean maximum temperature is consistently high (31–32°C) for all months, and the mean minimum temperature ranges from about 24°C in the mid wet season (January) to 18°C in the mid dry (July). Humidity is high for the greater part of the year.

Details of the seed sources represented in the trial are given in Table 1.
Table 1

Location and altitude of the provenance seed sources

<table>
<thead>
<tr>
<th>Seed No.</th>
<th>Seed Source</th>
<th>Country</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Altitude (Metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S7257</td>
<td>Dalat</td>
<td>Sth. Vietnam</td>
<td>11°57' N</td>
<td>108°30' E</td>
<td>1500</td>
</tr>
<tr>
<td>S7306</td>
<td>Shillong Reserve, Assam</td>
<td>India</td>
<td>25°34' N</td>
<td>92°00' E</td>
<td>1499</td>
</tr>
<tr>
<td>S9267</td>
<td>Nueva Vizcaya, Mt Tilasacara</td>
<td>Philippines</td>
<td>16°00' N</td>
<td>121°08' E</td>
<td>610</td>
</tr>
<tr>
<td>S9269</td>
<td>Coto Mine, Zambales</td>
<td>Philippines</td>
<td>15°32' N</td>
<td>120°07' E</td>
<td>914–1128</td>
</tr>
<tr>
<td>S9548</td>
<td>Samfya</td>
<td>Zambia (ex Philippines)</td>
<td>11°30' S</td>
<td>29°30' E</td>
<td>1270–1300</td>
</tr>
<tr>
<td>S9163</td>
<td>Kalaw Reserve</td>
<td>Burma</td>
<td>20°30' N</td>
<td>97°00' E</td>
<td>1300</td>
</tr>
<tr>
<td>S9502</td>
<td>Unknown</td>
<td>Malawi</td>
<td>2°00' – 15°47' S</td>
<td>33°00' – 35°00' E</td>
<td>1100–1700</td>
</tr>
</tbody>
</table>

*Pinus caribaea var. hondurensis*

D381    | Sliima Sia           | Nicaragua       | 14°45' N   | 83°53' W   | 50–100            |

Seedling stock 30–55 cm tall was raised in the nursery in small polythene bags. The containers were removed prior to hand planting in December 1974 at 3 × 3 metre spacing into mounded planting lines on well cultivated ground. Provenances were established in 10–tree line plots, randomly located in each of 3 replicate blocks. Maintenance in the first year of establishment included hand weeding and three NPKS fertiliser applications of 100 grams per tree.

An assessment at age 9 years embraced the growth and form traits listed in Appendix 1. This was based on procedures outlined by the Commonwealth Forestry Institute (1983).

Results

Figure 2 demonstrates the vastly superior growth of the Honduras Caribbean Pine seed source over all the *Pinus kesiya* provenances.

The assessment results for all traits are presented in Appendix 1 together with significance levels indicated by analyses of variance. Significant differences between the *P. kesiya* provenances were only obtained for mean height (see Figure 2) and number of whorls. The Zambian seed source was found (Duncan's multiple-range test, P=0.05) to have a significantly greater number of whorls than any other provenance.

In addition to the obvious growth differences, the Honduras Caribbean Pine source also had a higher percentage of bark, greater internode length (fewer whorls) and a higher incidence of both forks and broken tops than *P. kesiya*.
Discussion

Honduras Caribbean Pine was adopted as the main plantation species in the Northern Territory from about 1972/73, and its superiority is clearly evident in this trial.

The relatively poor growth of *P. kesiya*, and complete absence of any flowering or coning, appears consistent with the observation by Armitage and Burley (1980) that this species does not grow well in the low humid tropics. Few notable differences are apparent between the *P. kesiya* provenances in this trial, but it is possible that these have been suppressed under the climatic regime of this region.

The observations from this trial are seen as complementary to the broader study of *P. kesiya* growth in extensive international trials. Information from a diverse range of sites will enhance the evaluation of provenance performance, and better define the environmental limits for successful growth of this species in the tropics.

Acknowledgement

Members of the Division of Forest Research, CSIRO were responsible for the initiation and establishment of this trial.

REFERENCES


APPENDIX 1
Trait assessment summary at age 9 years for *P. kesiya* trial E.P. 476, Melville Island

<table>
<thead>
<tr>
<th>Trait Assessed</th>
<th>Dalat</th>
<th>Assam</th>
<th>Kalaw Reserve</th>
<th>Neusa Vizcaya</th>
<th>Zambales</th>
<th>Malawi</th>
<th>Zambia</th>
<th>Significance of <em>P. kesiya</em> provenance effects</th>
<th>P. caribaea</th>
<th>Sig. of overall prov. effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean trait performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (m)</td>
<td>8.80</td>
<td>7.32</td>
<td>6.50</td>
<td>7.74</td>
<td>8.28</td>
<td>8.27</td>
<td>8.38</td>
<td>*</td>
<td>13.17</td>
<td>***</td>
</tr>
<tr>
<td>Bark (% of BA. ob.)</td>
<td>24.03</td>
<td>29.34</td>
<td>32.25</td>
<td>27.06</td>
<td>29.26</td>
<td>23.59</td>
<td>28.17</td>
<td>N.S.</td>
<td>32.05</td>
<td>*</td>
</tr>
<tr>
<td>No. of whorls</td>
<td>13.56</td>
<td>16.39</td>
<td>13.75</td>
<td>16.83</td>
<td>16.61</td>
<td>14.93</td>
<td>19.70</td>
<td>**</td>
<td>10.87</td>
<td>***</td>
</tr>
<tr>
<td>Straightness score</td>
<td>16.81</td>
<td>11.61</td>
<td>15.31</td>
<td>13.30</td>
<td>9.80</td>
<td>12.13</td>
<td>13.88</td>
<td>N.S.</td>
<td>17.40</td>
<td>N.S.</td>
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<tr>
<td>Upper stem score</td>
<td>2.00</td>
<td>1.96</td>
<td>1.76</td>
<td>1.75</td>
<td>1.52</td>
<td>2.04</td>
<td>1.88</td>
<td>N.S.</td>
<td>2.20</td>
<td>N.S.</td>
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<tr>
<td>Stem lean score</td>
<td>1.10</td>
<td>1.41</td>
<td>1.28</td>
<td>1.44</td>
<td>1.31</td>
<td>1.43</td>
<td>1.48</td>
<td>N.S.</td>
<td>1.13</td>
<td>N.S.</td>
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<tr>
<td>Max. internode (m)</td>
<td>0.91</td>
<td>0.65</td>
<td>0.67</td>
<td>0.58</td>
<td>0.66</td>
<td>0.74</td>
<td>0.60</td>
<td>N.S.</td>
<td>1.29</td>
<td>**</td>
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<tr>
<td>Branches per whorl</td>
<td>3.37</td>
<td>3.10</td>
<td>3.23</td>
<td>3.22</td>
<td>3.00</td>
<td>3.45</td>
<td>3.53</td>
<td>N.S.</td>
<td>3.07</td>
<td>N.S.</td>
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<tr>
<td>Branch thickness score</td>
<td>3.12</td>
<td>2.93</td>
<td>3.42</td>
<td>3.00</td>
<td>2.37</td>
<td>3.04</td>
<td>2.66</td>
<td>N.S.</td>
<td>2.73</td>
<td>N.S.</td>
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<tr>
<td>Trait occurrence – percentage of trees</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Survival</td>
<td>96.6</td>
<td>96.6</td>
<td>96.6</td>
<td>93.3</td>
<td>96.6</td>
<td>93.3</td>
<td>90.0</td>
<td>N.S.</td>
<td>100</td>
<td>N.S.</td>
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<tr>
<td>Forking</td>
<td>10.0</td>
<td>13.3</td>
<td>10.0</td>
<td>20.0</td>
<td>13.3</td>
<td>16.6</td>
<td>16.6</td>
<td>N.S.</td>
<td>23.3</td>
<td>*</td>
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<tr>
<td>Ramicorns</td>
<td>46.6</td>
<td>50.0</td>
<td>56.6</td>
<td>60.0</td>
<td>43.3</td>
<td>56.6</td>
<td>36.6</td>
<td>N.S.</td>
<td>66.6</td>
<td>N.S.</td>
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<tr>
<td>Basket whorls</td>
<td>50.0</td>
<td>40.0</td>
<td>43.3</td>
<td>36.6</td>
<td>16.6</td>
<td>30.0</td>
<td>26.6</td>
<td>N.S.</td>
<td>50.0</td>
<td>N.S.</td>
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<tr>
<td>Broken tops</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>3.3</td>
<td>NIL</td>
<td>3.3</td>
<td>NIL</td>
<td>N.S.</td>
<td>13.3</td>
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EFFECTS OF RESIN EXTRACTION ON OPTICALLY DETERMINED DENSITY OF PINUS CARIBAEA MORELET AND P. OOCARPA SCHIEDE

By P. KANOWSKI and J. WRIGHT*

SUMMARY

Densities of Pinus caribaea Morelet and P. oocarpa Schiede were determined optically, before and after resin extraction. Although the extraction did not significantly alter the ranking of densities, absolute density values were significantly reduced.

RESUME

La densité du bois de Pinus caribaea et de P. oocarpa fut déterminée avant et après extraction de la résine. Cette opération ne changea pas les valeurs relatives de façon significative, mais elle fit baisser les valours absolues.

RESUMEN

La densidad de la madera de Pinus caribaea Morelet y P. oocarpa Schiede fue estimada por métodos ópticos antes y después de la extracción de resina. Aunque la extracción no cambió el orden de la densidad, los valores absolutos se redujeron significativamente.

Introduction

X-ray densitometry is used at the Commonwealth Forestry Institute (CFI), Oxford, to assess wood density. The wood of coniferous species frequently contains appreciable amounts of resin. This note reports comparison of densities assessed before and after resin extraction from cores of Pinus caribaea Morelet and P. oocarpa Schiede.

Methods

Bark to bark increment cores of 8 mm diameter were collected at about breast height from the material listed in Table 1. Cores were air-dried, machined to 5 mm thickness in both radial and axial planes and conditioned to 12% moisture content. They were then X-rayed and densities determined according to the method described by Hughes and Sardinha (1975). Resin was then extracted with a solvent of one part ethyl alcohol and two parts benzene by refluxing in a Soxhlet condenser for 24 hours. The cores were dried in a vacuum oven before reconditioning and radiography.

* C/O Commonwealth Forestry Institute, Oxford.
Density was determined at 200 micron intervals along both radii of each core. The mean density for a section is calculated thus:

\[ p = p_i a_i / a_i \]

where \( p_i = \) density at the \( i \)th interval

\( a_i = \) area of the \( i \)th interval, assuming circular rings.

In the Australian material, each radius was divided into thirds, with boundaries estimated from diameter measurements at 4 and 7 years. In the Zambian material, rings were visually determined to correspond to annual growth.

**Analyses**

For each set of materials, density parameters of corresponding rings were compared using Student’s t-test for paired data (Snedecor and Cochran, 1980 p85). In all cases, cores were significantly (\( p<0.01 \)) lighter after resin extraction. The rankings of mean, maximum and minimum ring density within sets were compared by calculation of Spearman’s rank correlation coefficient (Snedecor and Cochran 1980 p192). Rankings of extracted and unextracted densities in each of the three sets were significantly (\( p<0.01 \)) correlated: results are present in Table 2. This coefficient was also calculated from corresponding mean tree values reported by Burley and Palmer (1979) for *P. caribaea* var. *hondurensis* Barr. and Golf. from Fiji. Its value for the means of 20 trees was 0.99 (significant at \( p<0.01 \)).

**Table 2.**

Analytical results.

<table>
<thead>
<tr>
<th>Species</th>
<th>Mean density</th>
<th>Extractives (%) of extracted density</th>
<th>Spearman’s rank correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>unextracted</td>
<td>extracted</td>
<td>mean</td>
</tr>
<tr>
<td><em>P. caribaea</em> var. <em>hondurensis</em></td>
<td>0.589</td>
<td>0.572</td>
<td>3.0</td>
</tr>
<tr>
<td><em>P. caribaea</em> var. <em>caribaea</em> and var. <em>hondurensis</em></td>
<td>0.400</td>
<td>0.381</td>
<td>5.0</td>
</tr>
<tr>
<td><em>P. oocarpa</em></td>
<td>0.468</td>
<td>0.460</td>
<td>1.7</td>
</tr>
</tbody>
</table>
Discussion
Stonecypher and Zoebel (1966) reported a genetic correlation of 0.99 between extracted and unextracted densities of *P. taeda* L. in which extractive content was 1.0%. A similar value for *P. caribaea* var. *hondurensis* was reported by Burley and Palmer (1979). Although the resin content of our samples was greater, similar in magnitude to that reported by Cown *et al* (1983) for Fijian-grown *P. caribaea* var. *hondurensis*, rankings of densities were not significantly altered by resin extraction. However, our results suggest that the absolute value of optically determined softwood density may be appreciably overestimated if resin is not extracted.

Acknowledgements
The Conservator of Forests, Queensland, Australia, allowed use of the Australian material. The Zambian material derives from the cooperative assessment programme of the International Provenance Trials of *P. caribaea* and *P. oocarpa*, funded by the Overseas Development Administration and coordinated at the Commonwealth Forestry Institute.

REFERENCES
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DEVELOPING BOLE WOOD VOLUME EQUATIONS FOR A GROUP OF TREE SPECIES OF CENTRAL AMAZON (BRAZIL)

By N. HIGUCHI (1) and W. RAMM (2)

SUMMARY

Individual tree volume equations were developed for tropical rainforest species in the dry land area of Manaus, Amazonas State, Brazil, based on felled tree measurements. Several alternative relationships were analysed; the four best models are presented. Family-specific individual tree volume models are also presented for three separate families. All models use diameter of breast height (dbh) and commercial height to estimate gross volume including bark. One of the best volume equations was the Schumacher-Hall model.

RESUME

Les auteurs ont développé des équations pour le volume des arbres individuels des espèces trouvées sur les terrains émergés de Manaus, Bresil. Plusieurs modèles ont été analysés: les quatre meilleurs sont présentés. Des modèles spécifiques à la famille sont introduits pour trois familles. Tous les modèles se servent du diamètre à hauteur d'homme et à la hauteur commercializable, pour estimer le volume brut avec écorce. Un des meilleurs est l'équation Schumacher-Hall.

RESUMEN

Se desarrollaron ecuaciones de volumen para árboles individuales de la selva húmida tropical de terra firme cerca de Manaus (capital Estado de Amazonas) sobre la base de mediciones de árboles cortados. Varias relaciones alternativas fueron analizadas y los cuatro modelos mejores son presentados. Se presentan también modelos volumétricos individuales para las tres familias botánicas mas abundantes. Todos los modelos utilizan diámetro a 1.3 m (DAP) y la altura comercial para estimar volumen bruto en metros cúbicos con corteza. Uno de los ecuaciones me mejores fue la de Schmacher-Hall.

RESUMO

Foram desenvolvidas equações de volume comercial para cada árvore, individualmente, de floresta tropical úmida de terra firme na região de Manaus (Capital do Estado do Amazonas), com base em medições de árvores derrubadas. Várias relações alternativas foram analisadas e os 4 melhores modelos são apresentados. Os modelos volumétricos individuais são também apresentados para as 3 famílias botânicas mais abundantes, separadamente. Todos os modelos usam DAP e altura comercial para estimar volume bruto em metros cúbicos com casca. Uma das melhores equações de volume foi a de Schumacher-Hall.

(1) Graduate student at Michigan State University and former head of Department of Tropical Silviculture of INPA, Manaus, AM, Brazil.
(2) Associate Professor at Michigan State University, Department of Forestry, East Lansing, MI, U.S.A.
Introduction

The Brazilian Amazon is a huge resource – it occupies almost 5 M km$^2$ and has more than 4,000 different tree species. However, very little has been done in terms of volume estimation. Heinsdijk (1965) developed a volume equation for use in forest inventory in the Oriental Brazilian Amazon, and Fernandes et al. (1984) developed volume equations for Manaus County in the State of Amazonas. Most companies or institutions which have carried out forest inventories in the Brazilian Amazon use their own locally developed volume equations for estimating volume, other companies are still using Heinsdijk’s equation.

This lack of adequate information is mainly due to the under utilization of the Amazon forests. Even today, many Amazon forest industries are still being supported with residuals from clearcutting for agricultural purposes. Currently, very little of the Amazon dry land region is subjected to forest exploitation or management. This situation will change; as it changes, estimation of the volume of timber resources will become very important for proper management. There will be no way to get reliable estimates for forest management plans without good volume equations for each specific area.

The purpose of this study is to develop and present the best model for estimating individual volume of selected tree species of the Amazon’s tropical dry land forests. The results are expected to be used in forest inventory planning in the Manaus region.

Procedures

The following data were collected from 715 felled trees: volume including bark expressed in m$^3$ (V), diameter at breast height in cm (D) and commercial height in m (H). Commercial height was defined as that point on the upper stem where branches, roughness or other defects render the remaining length unmerchantable. The trees were used in a study of biomass and energy production conducted by the Department of Silviculture of the National Institute for Research in the Amazon (INPA) at the Tropical Silviculture Experiment Station, some 95 km North of Manaus city, the Capital of Amazonas State (Fig. 1). The study area can be defined by the following coordinates: between 2°37'S and 2°38'S and between 60°12'W and 60°14'W.

The group of species selected for biomass research is commonly used for fuelwood in the region. However, it also includes valuable timber species, e.g., *Pithecolobium racemosum* Ducke, *Dipteryx odorata* (Aubl.) Willd., *Clarisia racemosa* R. et P., *Nectandra ruba* (Mez) C. K. Allen, *Oualea paraensis* Ducke, *Brosimum rubescens* Taub., *Caryocar villosum* (Aubl.) Pers., *Caryocar pallidum* A. C. Smith, and *Diptropis purpurea* (Rich.) Amsh. var. *coriacea* Ducke. The complexity of the resource can be shown by the fact that the selected group of species is composed of 51 listed common names representing 166 species, 74 genera and 19 families. These species are representative of the floristic composition of Amazonian natural dry land tropical rainforest. Such species commonly have a specific gravity of approximately 0.60 g/cm$^3$. The three most abundant families are Sapotaceae, Leguminosae and Lecythidaceae, and within them, respectively, the most common genera are: (1) *Chrysophyllum*, *Micropholis*, *Richardella*, *Eclinusa*, *Pouteria* and *Ragala*; (2) *Pithecolobium*, *Dipteryx*, *Parkia*, *Enterolobium*, *Hymenaea*, *Inga*, *Swartzia*, *Eperua*, *Andira*, *Sclerolobium* and *Tachigalia*; and (3) *Coryphophora*, *Holopyxidium*, *Lecythis* and *Eschweilera*.

The trees were randomly selected from the biomass project area. Diameters were taken for each bole section; section length was defined as being equal to 10 per cent of
commercial height. Smalian’s geometric formula was used to calculate volume for each section. Section volumes were summed to estimate total bole and bark volume for each individual tree. Table 1 presents the basic distributional characteristics of dbh, height, and volume.
Table 1.
Basic distributional characteristics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Variance</th>
<th>C.V. (%)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(cm)</td>
<td>39.51</td>
<td>321.87</td>
<td>45.4</td>
<td>12.0</td>
<td>128.0</td>
</tr>
<tr>
<td>H(m)</td>
<td>15.11</td>
<td>15.00</td>
<td>25.6</td>
<td>6.2</td>
<td>27.0</td>
</tr>
<tr>
<td>V(m³)</td>
<td>2.17</td>
<td>7.31</td>
<td>123.7</td>
<td>0.06</td>
<td>28.0</td>
</tr>
</tbody>
</table>

Model Development

All computations were done by using SPSS on the CDC Cyber 170 model 750 at Computer Centre of Michigan State University.

Four volume models were selected after testing the linear relationship between volume, dbh and commercial height. The Schumacher-Hall (1933) equation was also included, as it has been the best model in other parts of the Brazilian Amazon (Fernandes et al., 1984 and Scarduelli, personal communication), in the Amazon forests of Venezuela (Fernandes et al., 1984), and also in Sumatra (Abell, 1979). The models are:

\[ V = b_0 + b_1 D^2 \]
\[ V = b_0 + b_1 D^2 H \]
\[ \log V = b_0 + b_1 \log D^2 H \]
\[ V = b_1 D^2 H \]
\[ \log V = b_0 + b_1 \log D + b_2 \log H \]

According to Loetsch et al. (1973) these 5 equations were, respectively, designated by: Kopezky-Gehrhardt, Spurr (combined variables), Spurr (logarithmic combined variables), Spurr (constant form factor), and Schumacher-Hall. All equations with an intercept coefficient were forced through the origin \((b_0=0)\) because theoretically there is no commercial volume without dbh and commercial height when one is working with energy production.

The criteria used in selecting the best models were similar to others used by Fernandes et al (1984), Abell (1979), Sandrasegaran (1972), and Burley et al. (1972). The exception was that the correction factor for bias in log-transformed equations (Sprugel, 1983) was used to calculate the Furnival index (Furnival, 1961). The criteria were the adjusted coefficient of determination \((R^2)\), the adjusted standard error of estimate, residual distributions and the Durbin-Watson (D-W) test. Table 2 presents

Table 2.
Pearson correlation coefficients between volume and the predictor variables – diameter and commercial height.

<table>
<thead>
<tr>
<th>Predictor Var.</th>
<th>Volume</th>
<th>log Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>log D</td>
<td>0.77**</td>
<td>0.97**</td>
</tr>
<tr>
<td>D²</td>
<td>0.77**</td>
<td>0.97**</td>
</tr>
<tr>
<td>log DH</td>
<td>0.72**</td>
<td>0.97**</td>
</tr>
<tr>
<td>log D²H</td>
<td>0.76**</td>
<td>0.99**</td>
</tr>
<tr>
<td>D</td>
<td>0.87**</td>
<td>0.91**</td>
</tr>
<tr>
<td>D²</td>
<td>0.95**</td>
<td>0.79**</td>
</tr>
<tr>
<td>DH</td>
<td>0.90**</td>
<td>0.89**</td>
</tr>
<tr>
<td>D²H</td>
<td>0.97**</td>
<td>0.77**</td>
</tr>
</tbody>
</table>
the Pearson correlations between volume and transformations of diameter and commercial height.

Individual regression analyses were also developed for the three most abundant families: Sapotaceae, Leguminosae and Lecythidaceae (Table 6). The resulting three regression lines were compared, to test whether three regression lines were identical (Neter & Wasserman, 1974).

**Results and Discussion**

The selected equations and associated measures of fit are presented in Table 3. Although Equation 7, $V = b_0 + b_1 D^{*2}H$, had a non-significant D-W test, its residual plots were not acceptable, *i.e.*, the error variance was not constant. Therefore, this equation was weighted inversely proportional to variance of volume (Freese, 1964), $w = 1/D^{*2}H$. The new weighted equation is presented as equation 9. Equation 5, $V = b_0 + b_1 D^{'2}$, which also had an inappropriate residual plot and an inconclusive D-W test, was weighted with $w=1/D^{'2}$. The weighted version became equation 10. The weighted equation $V/D^{'2}H = b_0/D^{'2}H + b_1$ improved in all aspects while $V/D^{'2} = b_0/D^{'2} + b_1$ still presented an inconclusive D-W test. Equations 5 and 7 were omitted from further analysis.

### Table 3.

Selected equations and measures of fit

<table>
<thead>
<tr>
<th>Equation no.</th>
<th>Adj.R²</th>
<th>Adj.SEE</th>
<th>D-W test</th>
<th>Furnival Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.98</td>
<td>0.072</td>
<td>1.96 ns</td>
<td>0.094</td>
</tr>
<tr>
<td>2</td>
<td>0.98</td>
<td>0.072</td>
<td>1.98 ns</td>
<td>0.094</td>
</tr>
<tr>
<td>3</td>
<td>0.97</td>
<td>0.074</td>
<td>2.01 ns</td>
<td>0.097</td>
</tr>
<tr>
<td>4</td>
<td>0.89</td>
<td>0.169</td>
<td>0.30 *</td>
<td>0.220</td>
</tr>
<tr>
<td>5</td>
<td>0.90</td>
<td>0.836</td>
<td>1.37 inc</td>
<td>0.836</td>
</tr>
<tr>
<td>6</td>
<td>0.94</td>
<td>0.869</td>
<td>1.11 *</td>
<td>0.869</td>
</tr>
<tr>
<td>7</td>
<td>0.95</td>
<td>0.630</td>
<td>2.08 ns</td>
<td>0.630</td>
</tr>
<tr>
<td>8</td>
<td>0.97</td>
<td>0.630</td>
<td>2.06 ns</td>
<td>0.630</td>
</tr>
<tr>
<td>9</td>
<td>0.97</td>
<td>0.130</td>
<td>2.00 ns</td>
<td>0.130</td>
</tr>
<tr>
<td>10</td>
<td>0.94</td>
<td>2.714</td>
<td>1.57 ns</td>
<td>2.714</td>
</tr>
</tbody>
</table>

* : significant with 95% confidence (positive serial correlation)
ns : non-significant: no serial correlation
inc: inconclusive

**EQUATION NO.**

1. $\log V = b_0 + b_1 \log D + b_2 \log H$
2. $\log V = b_1 \log D + b_2 \log H$
3. $\log V = b_0 + b_1 \log D^{'2}H$
4. $\log V = b_1 \log D^{'2}H$
5. $V = b_0 + b_1 D^{*2}$
6. $V = b_1 D^{*2}$
7. $V = b_0 + b_1 D^{'2}H$
8. $V = b_1 D^{'2}H$
9. $V/D^{'2}H = b_0/D^{'2}H + b_1$
10. $V/D^{'2} = b_0/D^{'2} + b_1$
Schumacher-Hall's equation, with and without intercept coefficient, once more was the best model in estimating volume of tree species of tropical rainforest. The regression ANOVAR, regression coefficients with respective standard errors and t-test are presented in Table 4. Besides these two equations, \( \log V = b_0 + b_1 \text{D}^{1/2}H \) and \( \frac{V}{\text{D}^{1/2}H} = \frac{b_0}{\text{D}^{1/2}H} + b_1 \) are also included in Table 4 in order to give the reader optional models for use.

**Table 4.**

Alternative volume equations

a) ANOVARs for four alternative equations

<table>
<thead>
<tr>
<th>Equation no.</th>
<th>Source Var.</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Regression</td>
<td>2</td>
<td>158.548</td>
<td>79.274</td>
<td>15574.4 **</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>713</td>
<td>3.629</td>
<td>0.005</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Regression</td>
<td>2</td>
<td>149.388</td>
<td>74.694</td>
<td>14740.6 **</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>712</td>
<td>3.608</td>
<td>0.005</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Regression</td>
<td>1</td>
<td>149.155</td>
<td>149.155</td>
<td>27688.1 **</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>713</td>
<td>3.841</td>
<td>0.005</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Regression</td>
<td>2</td>
<td>350.041</td>
<td>175.020</td>
<td>10312.2 **</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>713</td>
<td>12.101</td>
<td>0.017</td>
<td></td>
</tr>
</tbody>
</table>

b) Regression coefficients

<table>
<thead>
<tr>
<th>Equation no.</th>
<th>Coefficients</th>
<th>SE</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>( b_1 = 2.074 )</td>
<td>0.012</td>
<td>168.1 **</td>
</tr>
<tr>
<td></td>
<td>( b_2 = 0.889 )</td>
<td>0.005</td>
<td>174.4 **</td>
</tr>
<tr>
<td>1</td>
<td>( b_0 = 0.072 )</td>
<td>0.035</td>
<td>2.1 *</td>
</tr>
<tr>
<td></td>
<td>( b_1 = 2.096 )</td>
<td>0.016</td>
<td>127.8 **</td>
</tr>
<tr>
<td></td>
<td>( b_2 = 0.836 )</td>
<td>0.026</td>
<td>31.9 **</td>
</tr>
<tr>
<td>3</td>
<td>( b_0 = -0.164 )</td>
<td>0.003</td>
<td>-51.1 **</td>
</tr>
<tr>
<td></td>
<td>( b_1 = 1.009 )</td>
<td>0.006</td>
<td>166.5 **</td>
</tr>
<tr>
<td>9</td>
<td>( b_1 = -0.008 )</td>
<td>0.004</td>
<td>-2.1 *</td>
</tr>
<tr>
<td></td>
<td>( b_1 = 0.707 )</td>
<td>0.006</td>
<td>118.9 **</td>
</tr>
</tbody>
</table>

To check the stability of the regression coefficients, the best equation (Schumacher-Hall equation without intercept) was repeatedly fitted to subsets of the data, i.e., 25%, 50% and 75% randomly chosen from the total. The summary of these calculations is presented in Table 5. All levels and replications had appropriate residual distributions. Variations between minimum and maximum values of adjusted R², adjusted SEE, regression coefficients \( b_1 \) and \( b_2 \) were minor. Few differences could be detected when compared with the full model (100% of data), mainly because the minimum and maximum regression coefficients are within the 95% confidence interval for coefficients of the full model.

Table 6 is a summary of the individual regression models for the three most abundant botanical families, and for all three families combined. Even though numerically, the models look very similar, the F-test for identical lines is significant at the 99% confidence level. This test was repeated after removing 13 outliers indicated by regression analysis, but the test was still significant (i.e., these three regression lines
Possible explanations for the differences are either inadequate sample size for each family or simply because the variation within, is bigger than variation among families.

**Table 5.**
Testing the stability of regression coefficients for the Schumacher-Hall equation.

<table>
<thead>
<tr>
<th>Sample</th>
<th>trial</th>
<th>Adj.R^2</th>
<th>Adj.SEE</th>
<th>Coefficients</th>
<th>SE</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b1 =</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>0.97</td>
<td>0.079</td>
<td>2.060</td>
<td>0.027</td>
<td>77.6 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b2 =</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25%</td>
<td>2</td>
<td>0.98</td>
<td>0.071</td>
<td>2.038</td>
<td>0.024</td>
<td>83.8 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.870</td>
<td>0.010</td>
<td>89.1 **</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.97</td>
<td>0.077</td>
<td>2.028</td>
<td>0.028</td>
<td>72.1 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.876</td>
<td>0.011</td>
<td>76.7 **</td>
</tr>
<tr>
<td>50%</td>
<td>2</td>
<td>0.98</td>
<td>0.071</td>
<td>2.100</td>
<td>0.016</td>
<td>128.8 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.898</td>
<td>0.007</td>
<td>129.9 **</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.97</td>
<td>0.079</td>
<td>2.077</td>
<td>0.020</td>
<td>104.4 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.890</td>
<td>0.008</td>
<td>109.7 **</td>
</tr>
<tr>
<td>75%</td>
<td>2</td>
<td>0.98</td>
<td>0.070</td>
<td>2.076</td>
<td>0.014</td>
<td>146.9 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.886</td>
<td>0.006</td>
<td>152.3 **</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.98</td>
<td>0.071</td>
<td>2.069</td>
<td>0.014</td>
<td>147.5 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.888</td>
<td>0.006</td>
<td>151.4 **</td>
</tr>
</tbody>
</table>

**Table 6.**
Volume equations for the 3 most abundant families.

<table>
<thead>
<tr>
<th>Family</th>
<th>n</th>
<th>Adj.R^2</th>
<th>SSE</th>
<th>Coefficients</th>
<th>SE</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sapotaceae</td>
<td>101</td>
<td>0.96</td>
<td>0.78</td>
<td>b1 = 1.965</td>
<td>0.058</td>
<td>33.9 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b2 = 0.904</td>
<td>0.021</td>
<td>43.5 **</td>
</tr>
<tr>
<td>Leguminosae</td>
<td>88</td>
<td>0.98</td>
<td>0.38</td>
<td>b1 = 2.025</td>
<td>0.040</td>
<td>50.1 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b2 = 0.900</td>
<td>0.015</td>
<td>61.4 **</td>
</tr>
<tr>
<td>Lecythidaceae</td>
<td>110</td>
<td>0.98</td>
<td>0.39</td>
<td>b1 = 2.020</td>
<td>0.033</td>
<td>60.9 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b2 = 0.872</td>
<td>0.012</td>
<td>70.6 **</td>
</tr>
<tr>
<td>All 3 combined</td>
<td>299</td>
<td>0.97</td>
<td>1.74</td>
<td>b1 = 2.010</td>
<td>0.027</td>
<td>75.7 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>b2 = 0.893</td>
<td>0.010</td>
<td>92.2 **</td>
</tr>
</tbody>
</table>

b) test for identical lines

\[
\text{SSE(F)} = 1.54 \text{ (Full model)} \\
\text{SSE(R)} = 1.74 \text{ (Reduced model)} \\
F = ((1.74 - 1.54)/4)/(1.54/293) = 9.45 **
\]
c) volume equation after removing outliers.

<table>
<thead>
<tr>
<th>Family</th>
<th>n</th>
<th>Adj.$R^2$</th>
<th>SSE</th>
<th>Coefficients</th>
<th>SE</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sapotaceae</td>
<td>92</td>
<td>0.98</td>
<td>0.40</td>
<td>$b_1 = 2.034$</td>
<td>0.046</td>
<td>44.7 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$b_2 = 0.914$</td>
<td>0.016</td>
<td>57.0 **</td>
</tr>
<tr>
<td>Leguminosae</td>
<td>87</td>
<td>0.98</td>
<td>0.36</td>
<td>$b_1 = 2.021$</td>
<td>0.040</td>
<td>51.0 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$b_2 = 0.897$</td>
<td>0.014</td>
<td>62.2 **</td>
</tr>
<tr>
<td>Lecythidaceae</td>
<td>107</td>
<td>0.98</td>
<td>0.27</td>
<td>$b_1 = 2.027$</td>
<td>0.031</td>
<td>66.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$b_2 = 0.875$</td>
<td>0.011</td>
<td>76.9 **</td>
</tr>
<tr>
<td>All 3 combined</td>
<td>286</td>
<td>0.98</td>
<td>1.13</td>
<td>$b_1 = 2.033$</td>
<td>0.023</td>
<td>89.0 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$b_2 = 0.896$</td>
<td>0.008</td>
<td>108.1 **</td>
</tr>
</tbody>
</table>

d) test for identical lines

\[
SSE(F) = 1.03 \\
SSE(R) = 1.13 \\
F = ((1.13 - 1.03)/4)/(1.03/280) = 6.68 **
\]

**Conclusion**

Schumacher-Hall's volume equation, with and without intercept coefficient, was the best model in expressing volume for the study area. This equation can be used wherever the floristic composition is similar to the study area. As an example, it can be used in the whole Agricultural District of Superintendency of Duty free Zone of Manaus and in the Balbina Hydroelectric area. These areas have, respectively, 600,000 ha and more than 300,000 ha covered with typical dry land forest.

Single entry volume equations using dbh are very easy to use, but in this study, Kopezky-Gehrhardt's equation, equation 5, was not accurate, as shown by its residual distribution, even though its $R^2$ and SEE were very reasonable.

**REFERENCES**


SCARDUCELLI, J. Volume equation used in Jari Project area in 1980. (personal communication).

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RAPID EVALUATION OF TROPICAL FOREST BY THE RELATIVE OCCURRENCE OF BOTANICAL FAMILIES

By I. D. Hutchinson*

SUMMARY

In a tropical forest about which little is known, grouping standtables into botanical families shows in broad outline the forest structure and composition. It is a simple method for estimating initial commercial value and prospects, and suggesting ecological relationships. It provides a brief appraisal of the effects of harvesting and silvicultural treatment, thus helping guide procedures to be employed. An example from Malaysian Mixed Dipterocarp Forest is given, and the implications of silvicultural treatment discussed.

RESUME

Dans une forêt tropicale peu connue, l'on apperçoit les grandes lignes de la structure et de la composition en groupant les tables des peuplements par famille botanique. C'est une méthode simple qui permet d'estimer la valeur commerciale et les perspectives, tout en suggérant des effets de l'exploitation et du traitement sylvicole, et elle aide ainsi à établir des normes. Un exemple est étudié, pris dans la forêt malésienne à diptérocarpes, et la signification sylvicole est examinée.

RESUMEN

En un bosque tropical poco conocido, la agrupación de las tablas de existencia según las familias botánicas permite la visualización en grandes rasgos de la estructura y la composición del bosque. Es un método simple para estimar inicialmente el valor comercializable de un bosque y sus perspectivas, y para indicar los vínculos ecológicos. Además, proporciona una evaluación rápida de los efectos del aprovechamiento forestal y de los tratamientos silvícolas, orientando así las técnicas para la silvicultura y para el manejo. Se presenta un ejemplo tomado del bosque del trópico húmedo de Malasia, analizando las implicaciones del tratamiento silvícola.

Introduction

Grouping standtables into botanical families provides a preliminary vantage point from which to observe the composition and structure of a forest about which little is known. It distinguishes the families containing characteristically large trees, and helps the observer form an impression of the place occupied by certain families at different stages of ecological succession. It enables a quick appraisal of the effects of harvesting and of silvicultural treatments, thus guiding the formulation of procedures to be employed. Also, it can help suggest implications for the forest as a result of market expansion to absorb a wider range of species.

* FAO Forester, Tegucigalpa, Republic of Honduras.
The example quoted in this paper is drawn from Malaysian Mixed Dipterocarp Forest, as shown below,

<table>
<thead>
<tr>
<th>Years Elapsed Since Logging</th>
<th>Year of Enumeration</th>
<th>Location of Sample Forest Reserve</th>
<th>Watersheds in Sarawak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not logged</td>
<td>1974</td>
<td>Niah</td>
<td>Niah</td>
</tr>
<tr>
<td>F + 1</td>
<td>1974</td>
<td>Niah</td>
<td>Niah</td>
</tr>
<tr>
<td>F + 5</td>
<td>1974</td>
<td>Niah</td>
<td>Niah</td>
</tr>
<tr>
<td>F + 8</td>
<td>1979</td>
<td>Niah</td>
<td>Niah</td>
</tr>
<tr>
<td>F + 9</td>
<td>1978</td>
<td>Niah</td>
<td>Niah</td>
</tr>
<tr>
<td>F + 14</td>
<td>1979</td>
<td>Bukit Raya</td>
<td>Rajang</td>
</tr>
<tr>
<td>F + 23</td>
<td>1974</td>
<td>Batu Belah</td>
<td>Tutoh</td>
</tr>
<tr>
<td>F + 27</td>
<td>1978</td>
<td>Batu Belah</td>
<td>Tutoh</td>
</tr>
</tbody>
</table>

The table illustrates how, lacking other information, trends discussed in this paper assume the data to come from a single tract enumerated at intervals over a span of time almost equal to that required for one cutting cycle. This assumes that, after disturbance, a forest returns eventually to its pristine state (Kochummen, 1966; Martin, 1977). The author acknowledges that some differences taken to be the result of time, may in fact be caused by factors such as site and sample size. However, data depicting the effects of treatment (Appendix No. 3) involve no simulation, but are from repeated measurement of permanent plots.

The methodology enumerates all trees 10+ cms dbhob (Hutchinson, 1980). Trees were identified botanically by Forest Department staff selected for the task because of their consistent interest and ability in dendrology. The regional market deals in woods grouped according to colour and density. Consequently, in many instances, it was not necessary to identify trees further than generic level. Where genera contain some species of commercial value and others of no commercial value, field identification was intensified to fulfil requirements (Hutchinson, 1979b). At the time, the principal products were veneer and sawlogs; trees were harvested to a minimum cutting limit of approximately 60 cms dbhob. The market for species of secondary importance was probably the most restricted in the region, with the result that, in some cases, physical properties and wood-quality grouping had to be estimated from technical publications and conversations with experienced persons (Hutchinson, 1976).

**Indicated Family Characteristics**

General conclusions may be drawn from the diameter range recorded for a family, and the span of years after initial logging over which it is found to occur (Appendix No. 1).

First, the samples for the case under discussion suggest that many families containing desirable species are widely distributed, dominate the upper canopy but are commonly numerous in the lower canopy, mature at large diameters, and appear to survive competition well.

Second, Bombacaceae, Celastraceae, Dilleniaceae, Guttiferae, Meliaceae, and Tiliaceae, were recorded as occurring frequently in the smaller-diameter range, but less numerous in the larger. This suggests either maturity at a small-diameter, or weakness in competition. Due to the value of some of these woods, certain species might benefit from appropriate silvicultural treatment in youth.

On the other hand, families such as Apocynaceae and Thymeliaceae are more frequent in the larger-diameter range than in the smaller, suggesting a superior
EVALUATION OF TROPICAL FOREST

competitive ability. Applying silvicultural treatment to enrich this component of a stand could eventually reduce the amount of overall silvicultural treatment required.

In the large-diameter range, serious competition can be seen to come from Euphorbiaceae, Fagaceae, Myrtaceae, Annonaceae, Sapindaceae, Rosaceae and, to a lesser degree, from Ebenaceae and Moraceae. It would appear useful to monitor the ecology of species in these families, and to examine in depth their wood properties with the aim of determining whether any could be regarded as commercially desirable.

Finally, families liable to compete with desirable species in the small-diameter range are shown in Appendix 1B. Alangiaceae, Magnoliaceae, Rhizophoraceae, Theaceae, and Ulmaceae, were recorded as not appearing later than 10 years after logging, suggesting early mortality. If such proves to be the case, it is possible that trees of these families could become useful silvicultural tools, providing shade to discourage unwanted light-demanding pioneer species, and thus favouring “gap-opportunist” desirables (Baur, 1964).

Family Distribution

The relative occurrence of botanical families in forest which has been logged but has not received subsequent silvicultural treatment shows the relationship between commercial and non-commercial species; some of their characteristics can be deduced (Appendix No. 2).

Among trees in the large-diameter range (60 + cms dbhob), families containing at least one desirable species consistently comprise 75 to 90% of the mean total number of trees, and 80 to 90% of the mean total basal area. Of this, Dipterocarps comprise the greater portion. The relative occurrence of Anacardiaceae, Burseraceae, Lauraceae, Leguminosae and Sapotaceae is conspicuous. Most of the other families containing desirable species comprise more than one percent of the mean totals (Appendix No. 2A II).

In this size range, the relative occurrence of most botanical families appears to remain stable in relation to time elapsed after logging. Dipterocarpaceae increase, while Lauraceae and Leguminosae appear to become more sparse.

From information of this nature it is possible to list the families to be anticipated in any harvest. In this case, they include Anacardiaceae, Burseraceae, Dipterocarpaceae, Lauraceae and Leguminosae. Thus, whenever species in these families are encountered in the small-diameter range, they can be favoured by silvicultural treatment.

In the small-diameter range (10-59cms dbhob), families containing desirable species comprise 30-50% of the mean total number of trees, and 40-50%, of the mean total basal area. Dipterocarps comprise 10-20% of both the mean total number of trees and mean total basal area. Other families of importance are Anarcardiaceae, Burseraceae, Lauraceae, Mytristicaceae, and Sapotaceae (Appendix No. 2A.I)

Certain families occupy a relatively small proportion of the mean total basal area in the large-diameter range, but sustain a consistant representation in the small range and could perhaps be favoured to increase the harvestable stocking. Such families include Celastraceae, Guttiferae, Meliaceae, Mytristicaceae, Sapotaceae, Sterculiaceae, and Tiliaceae.

Families for which there is at present no commercial demand represent 10–25% of the number of large trees, 7–20% of the large tree basal area (Appendix 2 B .11). Action to decrease their stocking might yield an increase in the volume of exploitable timber. Large diameter, but undesirable species belong to many different families
each with a low frequency of occurrence. Those families which are most common include the Annonaceae, Combretaceae, Ebenaceae, Euphorbiaceae, Fagaceae, Moraceae and Rosaceae.

The ‘uneconomic’ families dominate the smaller (10–59 cms dbhob) size classes with 50–70% of the number of trees and 55–60% of the basal area (Appendix 2 B. 1). In order to guide future silvicultural treatment, it would be helpful to monitor the ecology of the tree species and to investigate their properties and potential uses. It is already known that while many members of the Euphorbiaceae are ephemeral, others grow to a considerable diameter and can be expected to occur consistently once a cutting cycle is established. Species which fail to reach 60 cm dbhob but may well influence the economic composition of the forest come from many families including the Ebenaceae, Euphorbiaceae, Flacourtiaceae, Moraceae and Myrtaceae. Many other families have species that can occasionally occur but would not influence forest management.

**Changes in family distribution following logging**

Assuming the investigated areas represented the development of a location during 30 years following logging, the families with one or more commercial species, represented at least 30% of the stocking of 10–59 cms dbhob trees and 40% of their basal area (Appendix 2A.1). In the 23 year plus and 27 year plus plots the percentages even exceeded those of the unlogged forest. However, many of these small, desirable trees were seen to be suppressed (Hutchinson, 1977, 1979a, 1979c). Appropriate silvicultural treatment might encourage more of them to survive and reach an economic size, possibly increasing the figures of 60+ cms dbhob economic trees above the observed minimum for the families of 75% of the number and 80% of the basal area. The desirable families are considered in alphabetical order.

**Anarcardiaceae:** Over the period, relative basal area per hectare was recorded as increasing in both diameter ranges. Rengas is a successful coloniser of open spaces and bare soil but, because of possible injuries to forest and sawmill workers caused by the caustic sap of many species in this family, any natural increase in stocking should be evaluated so as to decide whether that increase is desirable.

**Apocynaceae:** The relative occurrence of this family is limited. In the small-diameter range it remains constant over the period, but appears to rise conspicuously in the large-diameter range. This could imply that it competes well in post-logging conditions. Perhaps this population could be increased by appropriate treatment in the small-diameter range.

**Burseraceae:** In the small-diameter range, both relative stocking and basal area appear to decrease over the period simulated. In the large-diameter range, both numbers of stems and basal area increase after logging but, by the end of the period, fall to levels little above those recorded for unlogged forest. Silvicultural treatment would assist to maintain this increase and project it forward to the next cutting cycle.

**Dipterocarpaceae:** In both diameter ranges, the relative occurrence of dipterocarps shows a net doubling over the period, in terms of both mean numbers of trees and of basal area. This suggests the “gap-opportunist” nature of many dipterocarps able to take advantage of the conditions created by selective logging. Dipterocarps show a fall in relative occurrence at mid-span, because of competition from the “wave” of light-demanding secondary species.

**Lauraceae and Leguminosae:** Relative stocking in the small-diameter range appears to increase slightly over the period. There is a marked decrease in the large-diameter range. This difference suggests that a good response by natural regeneration following
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logging is prevented from reaching the upper canopy by trees of other families. Suitable treatment could assist trees of these two families to maintain a competitive position.

Meliaceae, Myristicaceae, and Sapotaceae: In the small-diameter range, the relative stocking of these families decreases to approximately half that recorded in unlogged forest. After reduction by logging, relative stocking in the large-diameter range appears to have increased by the end of the period, to a level almost equal to that recorded in unlogged forest. This suggests that the species concerned are strong competitors and follow a “wave” pattern set in motion by logging. Silvicultural treatment could help to sustain the stocking of immature trees of commercial value in these families.

Certain botanical families show no obvious change in relative stocking. Under current conditions they appear able to maintain naturally their position in the forest, regardless of the effects of logging. These families include Bombacaceae, Cecalarceae, Guttiferae, Sterculiaceae, and Tiliaceae. Some families, including the Dilleniaceae, Hypericaceae, Loganiaceae, and Thymelaeaceae were encountered so infrequently that trends in performance could not be established.

Throughout the simulated period, the relative stocking in the small-diameter range of families containing no commercially desirable species, remains constant at 50–70% of the mean total number of trees and 50–60% of the mean total basal area. It increases in mid-span due to the rush of light-demanding secondary species (Appendix 2B.1). In the large-diameter range, logging causes a sharp decrease in stocking. Further observations will be required to determine trends following this.

Euphorbiaceae: In terms of mean number of stems in the small-diameter range, the relative stocking of Euphorbiaceae increases to a maximum between F+10 years and F+25 years, after which it shows signs of declining. In the large-diameter range, the relative stocking remains constant, suggesting that many Euphorbiaceae mature at diameters smaller than 60 cm dbh. Post-logging conditions favour Euphorbiaceae. It becomes widely distributed throughout the lower canopy, and occupies a consistent position in the upper. As the aim of management in the forest under study is to produce veneer and sawlogs, it may be advisable to adopt a length of cutting cycle and a type of silvicultural treatment which discourages the proliferation of at least some Euphorbiaceae, while acknowledging the ecological importance of others in the family which function as a nurse crop for commercially desirable species. Final decisions will depend upon the results of observations of natural mortality in this family over future decades. But, during that period, it would be helpful to investigate wood properties thoroughly in order to utilise commercially as many Euphorbiaceae as possible.

Myrtaceae: For reasons which are not apparent, the relative frequency recorded for Myrtaceae in the small-diameter range decreases consistently over the period. As Myrtaceae colonise exposed soil, it appears an advantage to monitor their ecology.

The following families, also lacking desirable species, are common in occurrence but show little or no change in relative stocking, Annonaceae, Ebenaceae, Moraceae, Olacaceae, Polygalaceae, Rubiaceae, Sapindaceae, and Verbenaceae.

The Initial Effects of Silvicultural Treatment

In terms of mean numbers of trees in the small-diameter range, Appendix No. 3 compares the initial effects of different experiments in silvicultural treatment following a first selective logging. Contrasting figures, representing unlogged forest, and forest logged but not treated, appear in Appendix No. 2.
The removal of overmature stems, by poison-girdling stems 60+ cms dbhob, leaves the botanical diversity of the forest virtually unchanged. Other data shows a resulting modest increase in diameter increment (Hutchinson, 1981).

In the case of "liberation thinning", trees to be poison-girdled are chosen neither because of species nor size, but because of their physical position in relation to a selected potential final crop tree (Hutchinson, 1979c). Diameter increment increases and the forest remains botanically diverse. It is expected the incidence of Euphorbiaceae will increase, but not to ungovernable proportions, because of shade from the retained canopy.

In contrast, experimental application of the Malayan Uniform System (MUS), results in a sharp reduction in the number of botanical families. Dense secondary growth is concentrated among Euphorbiaceae, Dipterocarpaceae and, to a lesser degree, Moraceae. Enumeration eight years after MUS treatment showed desirable species growing more rapidly than under other treatments (Hutchinson, 1981). However, it is clear that woody climbers proliferate on MUS sites, and a period of intense competition among young trees can be expected.

Conclusions

Among the botanical families containing commercially desirable species in the case studied, Dipterocarpaceae and Burseraceae are strong competitors, while Lauraceae and Leguminosae are good competitors. Other families in the same group may be assumed to be weaker competitors, perhaps able to benefit from an appropriate silvicultural treatment to favour their position in the stand.

Of the families which contain no commercially desirable species, the majority are widely distributed in the small-diameter range. Members of both the Euphorbiaceae and Moraceae compete with more desirable species.

Silvicultural treatment by the Malayian Uniform System gives best initial growth increment, but botanical families disappear from the standtable while secondary growth is concentrated among only a few families. A treatment limited to removing the overmature trees rejected by logging, preserves intact the botanical diversity of the forest, but enhances growth increment only slightly. Liberation thinning increases growth increment, and maintains botanical diversity, thereby placing the forest in a favourable position with regard to any future market expansion.

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REFERENCES


Appendix No. 1: Characteristics of Botanical Families as suggested by occurrence recorded in eight sample tracts
(Minimum Occurrence One Percent of Mean Total)

A: Families containing at least one commercially desirable species

<table>
<thead>
<tr>
<th>BOTANICAL FAMILIES</th>
<th>Number of Sample Tracts in Which a Family Was Encountered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burseraceae</td>
<td>1 3 3 1 4 3 1 4 2 1 4 2</td>
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<tr>
<td>Dipterocarpaceae</td>
<td>1 4 3 1 4 3 1 4 3 1 4 3</td>
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<tr>
<td>Lauraceae</td>
<td>1 4 3 1 4 3 1 4 1 1 4 1</td>
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<tr>
<td>Leguminosae</td>
<td>1 4 3 1 4 3 1 4 1 1 4 1</td>
</tr>
<tr>
<td></td>
<td>2. Common occurrence, more so in lower canopy than in upper. Good competitors</td>
</tr>
<tr>
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<td>Myristicaceae</td>
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<td>Sapotaceae</td>
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<tr>
<td>Sterculiaceae</td>
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<tr>
<td></td>
<td>3. Either characteristically small at maturity, or not strong competitors</td>
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<tr>
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<td>Dilleniaceae</td>
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<td>Guttiferae</td>
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<td></td>
<td>4. Sparse occurrence. Apparently good competitors. Useful to encourage by silvicultural treatment</td>
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<tr>
<td>Thymeliaceae</td>
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Appendix No. 1B: Families Containing no commercially desirable species

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<td>Fagaceae</td>
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<td>Myrtaceae</td>
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<td>Rosaceae</td>
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5. Common. Strong Competitors. Dominant

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6. More common in lower canopy than upper. Good competitors

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7. Common in lower canopy. Tend to be either weak competitors, or characteristically small at maturity

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[continued over page]
Appendix No. 1B: Families Containing no commercially desirable species

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No trees over 60 cm dbhob in any of the 11 families

9. Lower canopy only. Characteristically small at maturity

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<th>Mean No. Trees/Ha</th>
<th>Mean Total BA/Ha</th>
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COMMONWEALTH FORESTRY REVIEW
Appendix No. 2: 27-Year Trends in the Relative Occurrence of Botanical Families.  
(Percentage of Mean Total Number of Trees per Hectare)

A: Botanical Families containing at least one commercially desirable species. (*indicates recorded occurrence of <1%)

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</table>

**SUB-TOTALS, APPENDIX 2A**

| Subtotal Percent | 42% | 42% | 39% | 34% | 34% | 32% | 43% | 47% | 79% | 88% | 81% | 75% | 78% | 79% | 89% | 89% |
| Mean No. Trees/Ha| 204 | 140 | 152 | 171 | 166 | 229 | 251 | 278 | 21 | 9 | 9 | 6 | 10 | 11 | 10 | 10 |
| No. Families 1+ %| 13 | 14 | 14 | 12 | 12 | 11 | 13 | 12 | 7 | 4 | 6 | 13 | 11 | 11 | 5 | 6 |

**TOTALS, APPENDICES 2A + 2B**

| Total Percent | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Mean No. Trees/Ha | 438 | 330 | 388 | 496 | 486 | 721 | 578 | 589 | 27 | 10 | 12 | 8 | 12 | 14 | 11 | 11 |
| No. Families 1+ % | 32 | 33 | 30 | 27 | 30 | 24 | 39 | 25 | 16 | 13 | 22 | 19 | 18 | 9 | 10 | 53 |
Appendix No. 2B: Botanical Families containing no commercially desirable species.

<table>
<thead>
<tr>
<th>BOTANICAL FAMILY</th>
<th>Not Logged</th>
<th>One Yr</th>
<th>5 Yrs</th>
<th>8 Yrs</th>
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**SUBTOTALS, APPENDIX 2B.**

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Appendix No. 3: The Initial effect of Silvicultural treatment upon the Relative Occurrence of Botanical Families.
(Percentage of Mean Total Number of Trees per Hectare, 10-59 cms dbhob)

A: Botanical Families containing at least one commercially desirable species. (*indicates recorded occurrence of <1%)

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**SUB-TOTALS, APPENDIX 3A**

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**TOTALS, APPENDICES 3A + 3B**

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ONE-YEAR PROVENANCE/PROGENY TEST RESULTS OF PINUS TECUNUMANII FROM GUATEMALA ESTABLISHED IN BRAZIL AND COLOMBIA

By D. W. DVORAK

SUMMARY

Mother tree seed collections were made of Pinus tecunumanii (Schw.) Equiluz and Perry in the provenances of San Jerónimo and San Lorenzo, Guatemala in 1980 and 1981. Provenance/progeny tests were established with the seed from these collections at 570 m, 1200 m and 2400 m elevation on three sites in Brazil and Colombia. Included in the tests were control lots of Pinus oocarpa Schiede from Mt. Pine Ridge, Belize and Chiquimula, Guatemala. Analyses of one-year height data indicates that at 2400 m elevation, the San Jerónimo provenance of P. tecunumanii statistically out performed the San Lorenzo source (mean height 96 cm vs. 84 cm). Also, at 2400 m elevation, ninety percent of the P. tecunumanii families from the San Jerónimo provenance grew as well as the Mt. Pine Ridge, P. oocarpa control. At the mid and low elevation sites (1200 m and 570 m) no statistical differences were detected in height growth between the two P. tecunumanii provenances; the Mt. Pine Ridge, P. oocarpa control was superior to P. tecunumanii. Pinus tecunumanii statistically out performed the P. oocarpa Guatemala control at 2400 m and 1200 m elevation; no differences were detected between the two species at the 570 m site.

RESUME

Des essais de provenance ont été établis sur trois placettes aux altitudes de 570 m, 1200 m et 2400 m, avec des graines de P. tecunumanii prises en Guatemala. Les données pour la hauteur à un an montrent une nette superiority pour la provenance San Jerónimo à 2400 m. A la même altitude 90% des familles de cette provenance dépassaient le contrôle de P. oocarpa. Aux altitudes moyenne et faible les provenances ne différaient pas de façon significative et se montraient inférieur au contrôle de P. oocarpa, provenance Guatemaleenee.

RESUMEN

Se recolectaron semillas de árboles padres de Pinus tecunumanii (Schw.) Equiluz and Perry de las procedencias de San Jerónimo y San Lorenzo, Guatemala en 1980 y 1981. Ensayos de procedencia y progenie se establecieron con semillas de estos recoltes a elevaciones de 570, 1200 y 2400 msnm a tres localidades en Brasil y Colombia. Los ensayos incluyeron ejemplares de P. oocarpa como control que provinieron del Mountain Pine Ridge en Belice y Chiquimula en Guatemala. El análisis estadístico del crecimiento en altura después de un año a 2400 msnm mostró que la procedencia San Jerónimo fue mejor que la de San Lorenzo (alturas promedias de 96 cm y 84 cm respectivamente). A una elevación de 2400 msnm también noventa por ciento de las familias de P. tecunumanii de San Jeronimo se desarrollaron tan bien como el ejemplar control de P. oocarpa.

Introduction

In its native habitat in Central America, *Pinus tecunumanii* (Schw.) Eguiluz and Perry is a magnificent species often reaching heights of 55 m with the first 30 m of the bole, free of lateral branches. The stem form is extremely straight and the crown is compact. During the mid 1970s’ only four or five small stands of the species were known to occur on mountain ridges in cloud forests above 1500 m elevation in Guatemala. Several additional sightings were also reported in the highlands of Honduras and El Salvador. Little attention was given to *Pinus tecunumanii* in Guatemala until the late 1970s’ when Mittak expressed concern that the few known provenances of the species were in jeopardy of being destroyed by farming and logging activities and subsequent bark beetle attacks. Primarily because of this concern, Eguiluz, in 1979, began intensive studies on the natural variation and taxonomy of *P. tecunumanii* in Guatemala (Eguiluz, 1982). The study included analyses of 29 morphological traits as well as analyses of wood quality and terpenes.

In 1980, the Central America and Mexico Coniferous Resources Cooperative (CAMCORE), at North Carolina State University, in collaboration with the Seed Bank of the National Forestry Institute (BANSEFOR/INAFOR) of Guatemala, began the first systematic seed collections ever conducted of *P. tecunumanii* in Guatemala. The objective of these collections was to conserve genetic material of endangered populations and to test the specie’s potential for afforestation and plantation programs throughout the tropics and subtropics (Dvorak, 1981). In 1981, with seed collected by the Cooperative and some given to CAMCORE by Eguiluz to broaden the genetic base of the specie, Cooperative members established conservation banks and provenance/progeny tests in Brazil, Colombia and Venezuela. These were the first known plantings of the Guatemalan sources of *P. tecunumanii*. This paper provides one-year results on the performance of two *P. tecunumanii* Guatemalan provenances planted on three diverse sites in Colombia and Brazil.

Readers should note that collections of *Pinus tecunumanii* vary somewhat in their identification. Those from the northern provenances (Mexico) collected by CAMCORE are referred to as *P. oocarpa var. ochoterenai*, Martínez by local foresters. Those from the southern provenances in Guatemala, Honduras and El Salvador are referred to as *Pinus tecunumanii*, distinct from *P. oocarpa var. ochoterenai* (Eguiluz and Perry, 1983). These authors conclude, however, that the range of *Pinus tecunumanii* probably extends into southern Mexico. Both *P. oocarpa var. ochoterenai* and *P. tecunumanii* are classified as being one and the same taxon, *Pinus patula* subspecies *tecunumanii*, (Schw.) Styles, by Barnes and Styles (1983). In this paper, the San Jerónimo and San Lorenzo sources are referred to as *P. tecunumanii*. When reference is made to the geographic range of this group which extends from Mexico to Nicaragua, the author will use the term “tecunumanii/ochoterenai complex” to indicate that several taxa may be included in this category. Only more detailed taxonomic studies in natural stands and assessment of progeny tests will determine if this is true.

---

2 Dr. Wilhelm Mittak, Food and Agriculture Organization (F.A.O.) specialist formerly with the National Forestry Institute (INAFOR), Guatemala.
Seed Collections

Cones on trees in the *tecunumanii/ochoterena* complex mature in as many as three flushes between October and March in Guatemala, CAMCORE's first cone collection in this complex occurred in November, 1980 in the provenance of San Jerónimo (elevation 1620–1850 m) and San Lorenzo (elevation 1910–2100 m), (Table I). Both provenances are located in the geologically same group of mountains which run in an east-west direction across central Guatemala and are separated by a distance of approximately 50 km. The San Lorenzo stand is over mature but still well stocked. The San Jerónimo stand is quite open as a result of sanitary thinnings by the National Forestry Institute (INAFOR) to remove trees infected by bark beetles. Annual rainfall amounts are estimated to be 1700–1800 mm to possibly as high as 2000 mm at San Lorenzo and about 1300–1600 mm at San Jerónimo (Table I).

### Table I

Information on 1980–1981 collection sites of *Pinus tecunumanii* in Guatemala

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<th>Provenance</th>
<th>Department</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Site Elevation (m)</th>
<th>Annual Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Jerónimo</td>
<td>Baja Verapaz</td>
<td>15° 03'N</td>
<td>90° 18'W</td>
<td>1620–1850</td>
<td>1300–1600</td>
</tr>
<tr>
<td>San Lorenzo</td>
<td>Zacapa</td>
<td>15° 05'N</td>
<td>89° 40'W</td>
<td>1900–2100</td>
<td>1700–1800</td>
</tr>
</tbody>
</table>

Seed collections in stands of both provenances were by individual mother tree. Dominant and codominant trees, some as tall as 60 m, were selected primarily on stem straightness and branch habit. It is believed that these traits are sufficiently highly heritable to allow good genetic gains in the first generation of improvement through simple mass selection, (Zobel and Talbert, 1984). Stem volume was given a second priority. In the collection, a minimum of 75 m was kept between selected trees to reduce the risk of pedigree relatedness. Isolated trees were avoided, whenever possible, to reduce the risk of obtaining inbred material. Small amounts of seed were obtained from twenty trees in each provenance. In late 1981 these seeds were distributed to four organizations in the CAMCORE Cooperative: Weyerhaeuser and Reforestadora Sacramento (RESA) in Brazil, Cartón de Colombia and the National Reforestation Company (CONARE) in Venezuela.

### Nursery Establishment

All organizations grew the *P. tecunumanii* seedlings in plastic containers (bags). Nursery soil was inoculated with mycorrhizae (*Pisolithus tinctorius* (Mich. ex Pers.) (Coker and Couch) at the proper time and fertilizer was applied at the required intervals in accordance with standard nursery practices acceptable from production of *P. caribaea* Morelet and *P. oocarpa* Schiede seedlings in the tropics and subtropics.
Test Designs

Weyerhaeuser, RESA and Cartón de Colombia established both conservation banks and provenance/progeny tests. CONARE only established a conservation bank because of problems experienced with seedlings development as explained in greater detail in the result section. Each organization included between 25 and 40 families in the conservation banks and between 15 and 21 families in the provenance/progeny tests. Ten families were common to all sites. The provenance/progeny tests were designed in a standardized randomized complete block experiment, replicated nine times with six tree family row plots (Dvorak, 1983). Families of each provenance were grouped together within each replication so that both provenance and family information could be obtained. The provenance/progeny tests were established on both low and high elevation sites from 570 m to 2400 m where annual rainfall amounts vary by as much as 1000 mm (Table II and III).

<table>
<thead>
<tr>
<th>Organization</th>
<th>Country</th>
<th>Location</th>
<th>Site Elevation(m)</th>
<th>Latitude &amp; Longitude</th>
<th>Annual Precipitation</th>
<th>Soil Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartón de Colombia</td>
<td>Colombia</td>
<td>Salinas</td>
<td>2400</td>
<td>2° 20’N 76° 32’W</td>
<td>2300 mm</td>
<td>Inceptisol, sandy loam, well drained</td>
</tr>
<tr>
<td>RESA</td>
<td>Brazil</td>
<td>Sacramento, M.G.</td>
<td>1200</td>
<td>19° 59’S 47° 19’W</td>
<td>1600 mm</td>
<td>Ultisol, sandy, well drained</td>
</tr>
<tr>
<td>Weyerhaeuser</td>
<td>Brazil</td>
<td>Morado Nova de Minas</td>
<td>570</td>
<td>18° 45’S 45° 10’W</td>
<td>1400 mm</td>
<td>Oxisol, well drained, high clay content</td>
</tr>
</tbody>
</table>

Table III

Family composition of *P. tecunumanii* provenance/progeny tests

<table>
<thead>
<tr>
<th>Tests</th>
<th>No. of Families San Jerónimo</th>
<th>No. of Families San Lorenzo</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartón de Colombia</td>
<td>10</td>
<td>11</td>
<td>21</td>
</tr>
<tr>
<td>RESA</td>
<td>8</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Weyerhaeuser</td>
<td>7</td>
<td>8</td>
<td>15</td>
</tr>
</tbody>
</table>
Analyses

Total height growth was measured to the nearest centimeter and an analysis of variance was conducted on data from the three sites using the generalized linear model procedure of the Statistical Analysis System® (Barr et al., 1979). Tests of significance were conducted on the main sources of variation and their interactions using Satterthwaite’s quasi-F ratio (Steel and Torrie, 1980). Family and control lot comparisons were made using the Duncan Multiple Range Test (Steel and Torrie, 1980).

Table IV
Information about collection sites of control lots used in *P. tecunumanii* provenance/progeny tests

<table>
<thead>
<tr>
<th>Species</th>
<th>Provenance</th>
<th>Department &amp; Country</th>
<th>Latitude &amp; Longitude</th>
<th>Site Elevation (m)</th>
<th>Annual Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. oocarpa</em></td>
<td>Mt. Pine Ridge</td>
<td>Cayo Belize</td>
<td>16° 58’ N</td>
<td>89° 00’ W</td>
<td>450–650</td>
</tr>
<tr>
<td><em>P. oocarpa</em></td>
<td>San José</td>
<td>Chiquimula, Guatemala</td>
<td>14° 40’ N</td>
<td>89° 57’ W</td>
<td>745–830</td>
</tr>
<tr>
<td><em>P. tecunumanii</em></td>
<td>San Jerónimo</td>
<td>Baja Verapaz, Guatemala</td>
<td>15° 03’ N</td>
<td>90° 18’ W</td>
<td>1620–1850</td>
</tr>
</tbody>
</table>

Results

Weyerhaeuser and RESA (Brazil) experienced no problems in producing plantable seedlings (15–20 cm tall) in five months or less. At Cartón (Colombia), seedling growth was slow to the point of being stagnant. There, 10 months were required to obtain plantable seedlings. At CONCARE (Venezuela), some seedlings grew normally while others in the same family remained stunted at heights of approximately 5 cm for as long as 4 months, after which they slowly produced secondary growth (Table V). Similar within family variability was also observed with *P. tecunumanii* growing in a nursery in Guatemala City (1500 m elevation) by the author. *Pinus oocarpa* developed normally in nurseries where *P. tecunumanii* grew poorly.

The causes for abnormal development of the *Pinus tecunumanii* seedlings are not known for certain, but it is thought that the problem is related to nursery potting medium rather than special mycorrhizae requirements or a genetics problem (i.e., highly inbred material producing abnormal development patterns). When establishing *P. tecunumanii* in the nursery in the future, nursery managers will be asked to use a potting medium which promotes good drainage, for example, two parts soil, two parts course sand, with no organic matter. This soil mixture should reduce the risk of seedlings becoming waterlogged, a problem which may have caused the stunting of the seedlings. Survival in the field was better than 90% at all three locations.
### Table V
Performance of *P. tecunumanii* in the nursery

<table>
<thead>
<tr>
<th>Organization</th>
<th>Elevation (m) of Nursery Site</th>
<th>Soil Mixture</th>
<th>Soil PH</th>
<th>Description of Growth</th>
<th>Time needed to Produce Plantable Seedlings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartón de Colombia</td>
<td>1750</td>
<td>1 pt. soil 2 pts sand</td>
<td>5.2</td>
<td>Uniform but extremely slow</td>
<td>10 months</td>
</tr>
<tr>
<td>CONARE (Venezuela)</td>
<td>1300</td>
<td>unknown</td>
<td>5–6</td>
<td>Extremely variable</td>
<td>10 months</td>
</tr>
<tr>
<td>RESA (Brazil)</td>
<td>1200</td>
<td>unknown</td>
<td>5–6</td>
<td>Uniform development; better than <em>P. oocarpa</em></td>
<td>5 months</td>
</tr>
<tr>
<td>Weyerhauser, (Brazil)</td>
<td>570</td>
<td>2 pts soil 1 pt. sand</td>
<td>5.6</td>
<td>Uniform development; steady, but slower than <em>P. oocarpa</em></td>
<td>4–5 months</td>
</tr>
</tbody>
</table>

### Table VI
Calculated F values for sources of variation in *P. tecunumanii* provenance/progeny tests at three sites

<table>
<thead>
<tr>
<th>Sources</th>
<th>Mean Squares</th>
<th>F value Calculation</th>
<th>Cartón (Salinas) Elevation 2400 m</th>
<th>RESA (Sacramento) Elevation 1200 m</th>
<th>Weyerhauser (Morada Nova) Elevation 570 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replications</td>
<td>MS1</td>
<td>MS1/MS3</td>
<td>2.58 (8,8)</td>
<td>0.21 (8,8)</td>
<td>5.39* (8,8)</td>
</tr>
<tr>
<td>Provenance</td>
<td>MS2</td>
<td>MS2+MS5</td>
<td>13.23** (1,22)</td>
<td>1.25 (1,19)</td>
<td>1.69 (1,19)</td>
</tr>
<tr>
<td>Reps. X Prov.</td>
<td>MS3</td>
<td>MS3/MS5</td>
<td>3.10 (8,152)</td>
<td>3.99** (8,103)</td>
<td>1.29 (8,104)</td>
</tr>
<tr>
<td>Fam. (provenance)</td>
<td>MS4</td>
<td>MS4/MS5</td>
<td>3.02** (19,152)</td>
<td>3.58** (13,103)</td>
<td>4.74** (13,104)</td>
</tr>
<tr>
<td>Fam. (Prov.) x Reps. Error</td>
<td>MS5</td>
<td>MS5/MSE</td>
<td>1.01 (152)</td>
<td>1.40 (103,662)</td>
<td>1.06 (104,629)</td>
</tr>
<tr>
<td>Within Plot</td>
<td>MSE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Significant .001 level

* Significant .01 level
The San Jerónimo provenance statistically out-performed the San Lorenzo provenance at Salinas (Colombia) 96 cm vs. 84 cm; no significant provenance differences were found at the mid and low elevation Sacramento and Morada Nova (Brazil) sites. (Table VI). Overall growth of *P. tecunumanii* improved with the increasing elevation of the planting site. Family differences were highly significant at all three sites. On the Morada Nova site (570 m elevation), which is more suitable for *P. caribaea* or *P. oocarpa*, the *P. oocarpa* checklots performed well. On the Salinas site (elevation 2400 m), which is probably better suited for *P. tecunumanii*, eight San Jerónimo families ranked above the Mt. Pine Ridge, *P. oocarpa* check (Table VII). The Mt. Pine Ridge source is considered to be one of the best performers in the highlands of Colombia. The *P. tecunumanii* checklot from a bulk collection in San Jerónimo ranked towards the bottom at both Salinas (Colombia) and Morada Nova (Brazil). Even though no across site analyses were conducted, it appears by the family rankings that genotype-site interactions will have to be considered in the future.

Table VII

Family ranking of 1 year height of *P. tecunumanii* and Duncan's Multiple Range Tests

<table>
<thead>
<tr>
<th>CARTÓN DE COLOMBIA</th>
<th>RESA (Brazil)</th>
<th>SACRAMENTO</th>
<th>Weyerhaeuser (Brazil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SALINAS (Elevation 2400 m)</td>
<td>SACRAMENTO (Elevation 1200 m)</td>
<td>MORADA NOVA (Elevation 570 m)</td>
<td></td>
</tr>
<tr>
<td><strong>Family</strong></td>
<td><strong>Mean Ht. (cm)</strong></td>
<td><strong>DMRT</strong></td>
<td><strong>Family</strong></td>
</tr>
<tr>
<td>SJ 103</td>
<td>103.2</td>
<td>MPR</td>
<td>SJ 202</td>
</tr>
<tr>
<td>SJ 84</td>
<td>100.3</td>
<td>SJ</td>
<td>SJ 84</td>
</tr>
<tr>
<td>SJ 10</td>
<td>99.2</td>
<td>SJ</td>
<td>SJ 47</td>
</tr>
<tr>
<td>SJ 102</td>
<td>98.8</td>
<td>SJ</td>
<td>SJ 100</td>
</tr>
<tr>
<td>SJ 100</td>
<td>98.5</td>
<td>SJ</td>
<td>SJ 86</td>
</tr>
<tr>
<td>SJ 99</td>
<td>96.8</td>
<td>SJ</td>
<td>SJ 200</td>
</tr>
<tr>
<td>SJ 101</td>
<td>96.7</td>
<td>SJ</td>
<td>SJ 101</td>
</tr>
<tr>
<td>P.o CHK**</td>
<td>Local 203</td>
<td>95.8</td>
<td></td>
</tr>
<tr>
<td>SJ 95</td>
<td>95.0</td>
<td>SJ</td>
<td>SJ 95</td>
</tr>
<tr>
<td>SJ 95</td>
<td>95.0</td>
<td>SJ</td>
<td>SJ 103</td>
</tr>
<tr>
<td>MPR 202</td>
<td>94.5</td>
<td>SJ</td>
<td>SJ 4</td>
</tr>
<tr>
<td>SJ 86</td>
<td>93.5</td>
<td>SJ</td>
<td>SJ 90</td>
</tr>
<tr>
<td>SJ 47</td>
<td>90.8</td>
<td>SJ</td>
<td>SJ 8</td>
</tr>
<tr>
<td>SJ 1</td>
<td>90.0</td>
<td>SJ</td>
<td>SJ 11</td>
</tr>
<tr>
<td>SJ 8</td>
<td>89.9</td>
<td>SJ</td>
<td>SJ 19</td>
</tr>
<tr>
<td>SJ 9</td>
<td>89.4</td>
<td>SJ</td>
<td>SJ 7</td>
</tr>
<tr>
<td>SJ 3</td>
<td>86.0</td>
<td>SJ</td>
<td>SJ 3</td>
</tr>
<tr>
<td>SJ 19</td>
<td>85.8</td>
<td>SJ</td>
<td>P.o CHK**</td>
</tr>
<tr>
<td>SJ 14</td>
<td>84.8</td>
<td>SJ</td>
<td>SJ 135</td>
</tr>
<tr>
<td>SJ 4</td>
<td>81.4</td>
<td>SJ</td>
<td>SJ 135</td>
</tr>
<tr>
<td>SJ 135</td>
<td>81.2</td>
<td>SJ</td>
<td>SJ 135</td>
</tr>
<tr>
<td>SJ 6</td>
<td>79.4</td>
<td>SJ</td>
<td>SJ 135</td>
</tr>
<tr>
<td>SJ 44</td>
<td>78.2</td>
<td>SJ</td>
<td>SJ 135</td>
</tr>
<tr>
<td>P.o CHK**</td>
<td>Guatemala</td>
<td>201</td>
<td>57.0</td>
</tr>
<tr>
<td>SJ 7</td>
<td>74.1</td>
<td>SJ</td>
<td></td>
</tr>
</tbody>
</table>

* Duncan's Multiple Range Test – means joined by a common line are not significantly different.

SJ is San Jerónimo, SL is San Lorenzo

P.o CHK** is *Pinus oocarpa* checklot, P.t CHK** is *Pinus tecunumanii* checklot, MPR is Mountain Pine Ridge
Discussion
The results of the performance of the two Guatemalan provenances are preliminary and should be viewed only as showing trends in variation. Only with complete analyses across site at later ages will tree breeders be able to determine superior provenances and families in the CAMCORE collections as well as in collections made by other international agencies. However, these early results suggest some provenance and large family differences are present and genetic gains can be made through provenance, family and individual tree selection and breeding.

Since the establishment of the first series of *P. tecunumanii* tests in late 1981, more has been learned about this potentially valuable complex. Intensive exploration activities in Guatemala by CAMCORE has led to the identification of new stands, thus indicating the *tecunumanii/ochoterena* complex is much more extensive than was originally thought in the late 1970s. Explorations in Honduras and reclassifications of some of the *P. oocarpa* stands as *Pinus tecunumanii* in Nicaragua by the Commonwealth Forestry Institute (CFI) has extended the previously known range of the complex further south (Barnes and Styles, 1983). Most interestingly, some of the stands identified by the CFI are located well below 1000 m elevation. 3

In efforts to conserve genetic material in the complex and provide Cooperative members with a broad genetic base, CAMCORE began its second series of collections in 1982. More intensive seed collections were made at San Jerónimo and San Lorenzo as well as San Vicente, La Soledad, KM 33 and KM 47 (Table VIII). Collections in the

### Table VIII

Information on the 1982–1983 collection sites of *tecunumanii/ochoterena* in Mexico, Guatemala, and Honduras (after Dvorak, 1984)

<table>
<thead>
<tr>
<th>Provenance</th>
<th>Country</th>
<th>State or Department</th>
<th>Latitude &amp; Longitude</th>
<th>Site Elevation (m)</th>
<th>Annual Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Jose</td>
<td>Mexico</td>
<td>Chiapas</td>
<td>16° 42' N 92° 41' W</td>
<td>2245–2400</td>
<td>1252</td>
</tr>
<tr>
<td>Las Piedrecitas</td>
<td>Mexico</td>
<td>Chiapas</td>
<td>16° 22' N 92° 09' W</td>
<td>2360–2500</td>
<td>1252</td>
</tr>
<tr>
<td>Chempi</td>
<td>Mexico</td>
<td>Chiapas</td>
<td>16° 45' N 92° 25' W</td>
<td>2020–2220</td>
<td>1146</td>
</tr>
<tr>
<td>Montebello</td>
<td>Mexico</td>
<td>Chiapas</td>
<td>16° 06' N 92° 45' W</td>
<td>1660–1750</td>
<td>1909</td>
</tr>
<tr>
<td>Jitotol</td>
<td>Mexico</td>
<td>Chiapas</td>
<td>17° 02' N 92° 51' W</td>
<td>1660–1750</td>
<td>1701</td>
</tr>
<tr>
<td>KM 33</td>
<td>Guatemala</td>
<td>Guatemala</td>
<td>14° 35' W 90° 22' W</td>
<td>2000–2200</td>
<td>1500–1600</td>
</tr>
<tr>
<td>KM 47</td>
<td>Guatemala</td>
<td>Jalapa Baja Verapaz and 15° 05' N 90° 07' W 1690–2200</td>
<td>1600–1800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>San Vicente</td>
<td>Guatemala</td>
<td>El Progresso</td>
<td>14° 31' N 90° 18' W 2390–2465</td>
<td>1540–2030</td>
<td>1500–1700</td>
</tr>
<tr>
<td>La Soledad</td>
<td>Guatemala</td>
<td>Jalapa</td>
<td>14° 33' N 88° 40' W 1540–2030</td>
<td>1500–1700</td>
<td></td>
</tr>
<tr>
<td>Celaque</td>
<td>Honduras</td>
<td>Lempira</td>
<td>14° 07' N 87° 49' W 2075–2185</td>
<td>1579</td>
<td></td>
</tr>
</tbody>
</table>

---

3 Personal communication with Colin Hughes, Research Officer, Unit of Tropical Silviculture. Commonwealth Forestry Institute, University of Oxford, England.
PROVENANCE/PROGENY RESULTS OF *Pinus tecunumanii* 65
tecunumanii/ochoterenaí complex expanded to include Honduras (1982) and Mexico (1983). The second seed distribution from this complex included 13 provenances and 380 mother trees from southern Mexico to central Honduras. Tests are now being planted in Brazil, Guatemala, Colombia, Republic of South Africa, Honduras and Mexico. Once results from these second series of CAMCORE tests are known, breeding strategy will be developed to utilize fully the best performances and families. In the meantime, explorations and collection activities will continue in Mexico, Guatemala and Honduras.

Conclusion

CAMCORE began making collections of *Pinus tecunumanii* in Guatemala in 1980 when little was known about the species. The first collections made were small but very important. Already some trees selected for collection in 1980 have been cut down to make way for the planting of annual crops. Intensive explorations by CAMCORE crews in 1981–1983 have led to more seed collections in new stands of *P. tecunumanii* in Guatemala; material from both Mexican and Honduran sources have greatly added to the value of the latest more complete tests. Conservation banks planted in several countries will serve as seedling seed orchards and future sources of seeds for *P. tecunumanii*. The genetic base of these important conservation banks will be enlarged through continued exploration for new genetic material and exchange of seeds with other interested international organizations.

REFERENCES


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GROWTH, FORM, AND FLOWERING OF CARIBBEAN PINE FAMILIES IN PUERTO RICO

By L. H. LIEGEL*

SUMMARY

Mean annual increments at 11.6 years averaged ≥ 1.4 m for heights of eight families and ≥ 2.0 cm for diameters of seven families. Best height and diameter growth were for families selected from low elevations (< 600 m) of Mt. Pine Ridge, Belize. Existing form was poor, with ≥ 81% of all trees having twisted stems; foxtailing was ≥ 31% for individuals in six families. Few individuals had fine branching and flat branch angle. Cone production was low, with only three families having a majority of individuals with ≥ 31 cones per tree. At 3.0 years, both male and female flowers were present, but at 11.6 years, female flowers predominated. At both assessments, flowering on trees in an eroded portion of the orchard was less than on trees in the non-eroded section.

RESUME

La moyenne de l'accroissement annuel était de ≥ 1.4 m pour la hauteur dans 8 familles, et de ≥ 2.0 cm pour le diamètre dans 7 familles. Les meilleurs valeurs étaient pour des familles sélectionnées à de basses altitudes de Mt. Pine Ridge, Belize. La forme était médiocre, ≥ 81% de tous les arbres ayant la tige contorsionnée; la forme en queue de renard se manifestait sur ≥ 31% des individus dans 6 familles. Peu de spécimens avaient des branches fines et horizontales. La production des cones était faible, et ne dépassait 31 cones par arbre que dans trois familles. A 3 ans les inflorescences males et femelles étaient également présentes, mais à 11.6 ans les femelles pré dominaient. Dans les deux cas la floraison était plus abondante dans les secteurs les moins érodés.

RESUMEN

Los incrementos anuales a los 11.6 años promediarán ≥ 1.4 m para alturas en ocho familias y ≥ 2.0 cm para diámetros en siete familias. El mejor crecimiento de altura y diámetro fueron en las familias seleccionadas de bajo elevación (<600 m) en Mt. Pine Ridge, Belize. La forma existente fue pobre, con ≥ 81% de troncos torcidos; cola de zorro fue ≥ 31% por individuos en seis familias. Algunos individuos tenían ganchos finos y angulo de ganchos planos. La producción de conos fue baja, con solamente tres familias con la mayoría de individuos con ≥ 31 conos por arbol. A los tres años ambas flores masculinas y femeninas estaban presentes, pero a los 11.6 años, predominaban las flores femeninas. En ambos periodos las flores en los árboles en una sección del huerto gastada por erosión fue menor que en los árboles en la sección no gastada por erosión.

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**Introduction**

*Pinus caribaea* Morelet var. *hondurensis* Barr. and Golf., known locally as Honduras pine, pino Hondureno, pino *caribaea* or Caribbean pine, is one of the most important forest species in tropical and subtropical regions. It offers a potential local source for posts, poles, and sawtimber, even when planted on steep and low-fertility lands unsuited for crops and other land uses. The species was added to Puerto Rico’s reforestation programmes in the mid 1960’s after adaptability trials showed that it outperformed most other pines and hardwood species (Geary and Briscoe, 1972).

Early observations on Caribbean pine growth and performance showed substantial variation in form and volume production among provenances (Nikles, 1972). International trials to improve growth and form by selection and breeding of provenances and trees within provenances have been underway for over two decades. One such effort by the Commonwealth Forestry Institute (CFI), United Kingdom, identified 100 plus-trees from Mt. Pine Ridge, Belize (Lamb and Burley, 1972), the seed source used for most plantings throughout the world through the early 1960’s (Nikles, 1972). Progeny from 16 of these 100 families were placed in a seed orchard-progeny trial in Puerto Rico in December 1971 by the Institutute of Tropical Forestry (ITF). Nursery data showed that factors influencing size of the plus-trees affected germination percent, germination vigor, and seedling height growth (Geary and de Barros, 1973). Field assessment of the trial at 6.5 years (Ledig and Whitmore, 1981) showed that these effects had disappeared and that:

- heritability for volume (0.11) and height (0.10) was moderate;
- heritability for bark thickness (0.53) was high;
- positive genetic correlation between foxtailing and vigour indicated that selection against foxtails could cause volume loss; but
- phenotypic correlations between some 11 other traits studied were low.

Criteria used in selecting the plus-trees at Mt. Pine Ridge were not well documented. Major emphasis was evidently on good stem and crown form as well as accessibility to local roads. Selecting phenotypically superior plus-trees from a wide geographical area may not produce superior progeny. Rather than represent fastest growers, plus-trees from large areas could represent both early colonists established after frequent natural wildfires and remnants from the original stand (I. Napier, in Ledig and Whitmore, 1981).

This report reassesses field results at 11.6 years from outplanting and also discusses long-term implications of these results for tree improvement.

**Materials and Methods**

Open-pollinated seed was distributed by CFI and ITF in 1969 from 16 plus-trees growing at elevations between 430 and 790 m on Mt. Pine Ridge (Commonwealth Forestry Institute, no date). Total heights of mother trees producing the seed ranged from 13 to 27 m and overbark diameters from 27.0 to 40.3 cm. No foxtailing was reported.
Seedlings from seed of the 16 plus-trees (families) were originally outplanted in 420cc peat plots at 3 m $\times$ 3 m spacing. Field design was 12 randomized blocks with 4-tree row plots and two border rows. The 0.8-ha site is 50 m above sea level, near Humacao in Southeastern Puerto Rico. Mean annual rainfall is about 2000 mm, well-distributed throughout the year. Life zone is subtropical moist forest (Ewel and Whitmore, 1973). Topography is gently sloping throughout, but one half of the orchard has suffered considerable loss of topsoil through localized erosion. Mayo sandy loam (Typic Dystropept) predominates on eroded portions and Panura loam (Typic Eutropept) on noneroded portions.

The first thinning in 1978, at 6.6 years, removed the worst-formed trees in all 4-tree plots there were no dead trees. A second thinning in 1980, at 8.4 years, rogued 8 of the 16 families, leaving 8. Roguing criteria were based on observations by Ledig and Whitmore (1981). Families left had higher indices for volume, freedom from foxtails, freedom from forking, and greater straightness than did rogued families.

For the reassessment in July 1983, at 11.6 years, heights were measured to the nearest 0.5 m with an altimeter, overbark breast height diameters were measured to the nearest 0.1 cm with a metal tape. Form categories were, twisted, leaning, forked, sweep, and outstanding (i.e. superior). Foxtail individuals had $\geq 1.2$ m of branchless area on current or oldgrowth portions of the main stem. Presence of new conelets and/or pollen was noted at 3.0 years and 11.6 years. At the latter age, presence of maturing cones was categorized in three classes: none, $\leq 30$, and $\geq 31$ cones per tree. Branch angle classes were: $< 45^\circ$, $45^\circ$ to $80^\circ$, and $\geq 81^\circ$. Branch size was defined as fine, intermediate, and coarse. Data on flowering, cones, form, branch angle, and branch size were taken ocularly at several points around each tree.
Height and diameter data (Table 1) were derived from plot means in nine replications having one or more surviving trees in all row plots. For determining microsite effect on height and diameter growth (Table 2), plot mortality and the balanced analysis of variance model used restricted observations to three replications on both eroded and noneroded portions of the trial site. For these six replications, plot means were the largest heights and diameters for two trees in each family. Significance level was \( \alpha = 0.05 \). Percentage data in Tables 3 to 5 were derived from observations of all surviving trees for all families.

### Table 1

Elevational origin and average total and range in heights and overbark breast height diameters for Mt. Pine Ridge, Belize plus-tree progeny in Puerto Rico at 11.6 years

<table>
<thead>
<tr>
<th>Family No.</th>
<th>Elevation (m)</th>
<th>Total Heads (m)</th>
<th>Total Diameters (cm)</th>
<th>Range Heads (m)</th>
<th>Range Diameters (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>606</td>
<td>16.7 b(^1)</td>
<td>25.9 a(^1)</td>
<td>13.8–19.2</td>
<td>21.7–28.1</td>
</tr>
<tr>
<td>7</td>
<td>606</td>
<td>17.3 b</td>
<td>24.6 ab</td>
<td>11.5–20.5</td>
<td>17.3–32.3</td>
</tr>
<tr>
<td>10</td>
<td>788</td>
<td>16.2 b</td>
<td>22.8 c</td>
<td>13.5–19.5</td>
<td>20.4–26.9</td>
</tr>
<tr>
<td>17</td>
<td>576</td>
<td>16.6 b</td>
<td>23.5 bc</td>
<td>14.5–18.0</td>
<td>21.8–25.9</td>
</tr>
<tr>
<td>19</td>
<td>667</td>
<td>16.4 b</td>
<td>22.1 c</td>
<td>13.7–19.0</td>
<td>17.5–26.2</td>
</tr>
<tr>
<td>28</td>
<td>455</td>
<td>17.0 b</td>
<td>22.9 bc</td>
<td>15.5–18.3</td>
<td>21.1–24.2</td>
</tr>
<tr>
<td>30</td>
<td>455</td>
<td>19.4 a</td>
<td>25.8 ab</td>
<td>16.0–21.5</td>
<td>24.6–27.1</td>
</tr>
<tr>
<td>33</td>
<td>424</td>
<td>16.5 b</td>
<td>24.1 abc</td>
<td>14.2–18.7</td>
<td>20.8–25.9</td>
</tr>
</tbody>
</table>

\(^1\) Means followed by the same letters are not statistically different, using Duncan’s new multiple range test, \( \alpha = 0.05 \).

### Table 2

Partitioning of experimental effects for height and diameter growth of Mt. Pine Ridge, Belize plus-tree progeny on eroded and noneroded portions of an orchard site in Puerto Rico

<table>
<thead>
<tr>
<th>Experimental Effects</th>
<th>Degrees of Freedom</th>
<th>Variance Component (%)</th>
<th>F – test (^1)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>1</td>
<td>13</td>
<td>7</td>
<td>*</td>
</tr>
<tr>
<td>Families</td>
<td>7</td>
<td>19</td>
<td>16</td>
<td>*</td>
</tr>
<tr>
<td>Replications</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>NS</td>
</tr>
<tr>
<td>Site x family</td>
<td>7</td>
<td>12</td>
<td>29</td>
<td>*</td>
</tr>
<tr>
<td>Site x replications</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>NS</td>
</tr>
<tr>
<td>Family x replications</td>
<td>14</td>
<td>15</td>
<td>9</td>
<td>*</td>
</tr>
<tr>
<td>Site x family x replications</td>
<td>14</td>
<td>17</td>
<td>12</td>
<td>*</td>
</tr>
<tr>
<td>Experimental error</td>
<td>48</td>
<td>20</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) \( \alpha = 0.05 \)

NS Not significant.
Results

Mean annual increments at 11.6 years averaged $\geq 1.4$ m for heights of all eight families and $\geq 2.0$ cm for diameters of seven families. Some differences in total heights and overbark diameters between families were significant (Table 1). Best height growth was for family 30 which came from a low elevation (457 m) on Mt. Pine Ridge. Elevational origin for top-ranked families in diameters was $\leq 606$ m. Correlations of family heights and diameters at 11.6 years with mother-tree heights and diameters, origin elevations, and nursery heights and germination percentages were not significant.

Differences existed in tree height and diameter growth between eroded and noneroded areas of orchard: mean total height and diameter for noneroded versus eroded areas were respectively 18.0 versus 16.5 m and 26.0 versus 24.2 cm. Site, family, and site x family interaction effects were significant (Table 2).

Form and cone production were not particularly good, even though inferior families were rogued earlier. More than 81% of remaining individuals had very twisted stems; foxtailing exceeded 22% for all but family 7 which also had no forking (Table 3). Sweep by itself was not a significant defect.

All families were flowering at the July 1983 assessment, with new conelets predominating over pollen production (Table 4). The tallest family, No. 30, had fewest non-flowering trees, 3%. The number of dried male catkins on the ground and hanging on branches indicated that male flowering had peaked prior to field assessment. At age 3, flowering has been fairly uniform among all families although much more limited on the eroded part of the orchard (Table 5). Only three families had more than 50% of individuals with $\geq 30$ maturing cones per tree in 1983; one of these was the tallest family but not one of them had the largest overbark diameters (Tables 1 and 4).

The majority of individuals in all families had acute branch angle and very coarse branching. Three of eight families had small percentages of individuals with flat branch angle, whereas five of eight had some individuals with fine branching. The tallest family had some individuals with both flat branch angle and fine branching.

Table 3

Form data for Mt. Pine Ridge, Belize plus-tree progeny in Puerto Rico at 11.6 years

<table>
<thead>
<tr>
<th>Family No.</th>
<th>No. Surviving Trees (n)</th>
<th>Foxtails</th>
<th>Twisted (% Surviving Trees)</th>
<th>Forked</th>
<th>Sweep</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>33</td>
<td>36</td>
<td>94</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>34</td>
<td>9</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>32</td>
<td>22</td>
<td>81</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>29</td>
<td>31</td>
<td>86</td>
<td>10</td>
<td>3</td>
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<tr>
<td>19</td>
<td>37</td>
<td>37</td>
<td>89</td>
<td>11</td>
<td>0</td>
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<tr>
<td>28</td>
<td>23</td>
<td>35</td>
<td>91</td>
<td>4</td>
<td>4</td>
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<td>30</td>
<td>32</td>
<td>31</td>
<td>91</td>
<td>9</td>
<td>0</td>
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<tr>
<td>33</td>
<td>32</td>
<td>34</td>
<td>91</td>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>
## Table 4
Flowers and Cone production for Mt. Pine Ridge, Belize plus-tree progeny in Puerto Rico at 11.6 years

<table>
<thead>
<tr>
<th>Family No.</th>
<th>Conelets</th>
<th>Actual flowers Catkins</th>
<th>None</th>
<th>Maturing Cones per Tree (%) Surviving Trees</th>
<th>0</th>
<th>30</th>
<th>≥ 31</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>76</td>
<td>0</td>
<td>24</td>
<td>3</td>
<td>52</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>82</td>
<td>3</td>
<td>18</td>
<td>3</td>
<td>59</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>84</td>
<td>0</td>
<td>16</td>
<td>0</td>
<td>63</td>
<td>37</td>
<td></td>
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<td>17</td>
<td>90</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>34</td>
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<td>89</td>
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<td>0</td>
<td>57</td>
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<td>91</td>
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<td>39</td>
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<td>30</td>
<td>97</td>
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<td>3</td>
<td>3</td>
<td>28</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>84</td>
<td>3</td>
<td>16</td>
<td>3</td>
<td>69</td>
<td>28</td>
<td></td>
</tr>
</tbody>
</table>

1 Number of surviving trees per family listed in Table 3. (n)

### Discussion and Conclusion

Mean annual height (1.4 to 1.7 m) and diameter (1.9 to 2.2 cm) increments in the progeny trial were still high at 11.6 years (Table 1). Values were slightly less than those (1.7 m and 2.0 cm) for Mt. Pine Ridge sources in 10-year-old CFI international P. caribaea trials in western Puerto Rico (Liegel, 1984), yet about the same as those (1.5 m and 1.8 cm) measured in 28 plantings, 5- to 14-years old, on diverse sites across the island (Liegel, 1983). In an adjacent CFI P. caribaea international trial including 13 provenances, the Mt. Pine Ridge source at 4.9 years had the highest mean annual height increment, 2.1 m, and the third-highest mean annual diameter increment, 3.2 cm. Although the Mt. Pine Ridge source is one of the fastest growers in Puerto Rico at low and high elevations, elsewhere it is usually outranked in volume production by several other inland and coastal sources, at least in CFI trials 5- to 8-years old (Gibson et al., 1983b).

Even after removing eight families that showed poorest growth and form, the remaining families still had a high percentage of twisted, forked, and foxtail trees. Either phenotypic selection of the mother trees was ineffective or the Mt. Pine Ridge population is characteristically rough and coarse in growth habit. Future breeding requires larger base populations and more intense selection to break good growth-poor form correlations (Ledig and Whitmore, 1980).

Although foxtail percentage was ≥ 31% for six families (Table 3), 1983 assessment values may reflect some benefit from thinning. Foxtail individuals were cut from some families at the first thinning in 1978. At the nearby CFI provenance trial, foxtailing for the Mt. Pine Ridge source was 40%. In other CFI provenance trials 4- to 6-year old, the Mt. Pine Ridge source has averaged 28% across eight sites; the range was 13 to 44% (L.H. Liegel, unpub. data).

Flowering at 3 years in the orchard was earlier than that described in other countries (Greaves, 1980; Gibson et al., 1983a) Early flowering for the Mt. Pine Ridge source has also been documented at Anasco, in the western part of the island. Soils around Anasco are deep, low pH Ultisols instead of sandy Inceptisols, yet climatic conditions are similar to those near Humacao. In 5-year-old CFI P. caribaea trials near Anasco, only 3 of 16 provenances had more conelets than did the Mt. Pine Ridge source.
Other significant observations at age 3 in the orchard site were: 1) that male flowering occasionally predominated over female flowering and 2) that both female and male flowering were influenced by microsite fertility (Table 5).

Gibson (1982) attributed provenance flowering differences to climatic rather than edaphic control. Fertilization and irrigation are both used to: a) stimulate flower initiation and, b) increase flower numbers in commercial seed orchards (Schultz, 1971). The implication for Caribbean pine seed orchard management is clear. First, select fertile orchard sites that are as uniform as possible to maximize seed production. If orchard sites have fertility gradients, then a detailed soil management plan should be prepared which takes existing site gradients into account. Second, orchard sites should be located in areas having a definite wet and dry seasonal climate. Drier climates stimulate early flowering and promote synchronization of flowering to maximize cone and seed yields.

Finally, mere presence of male and female flowers and cones at early ages does not guarantee good seed production. Preliminary observations on a few cut cones indicate that seed yield per cone at 10 years in the orchard was only 12 to 15 seeds; the viability of these seeds was not tested. Because family 31 was one of the fastest growers and still had a large number of maturing cones, there did not appear to be a negative correlation between high cone yields and growth rate.

**Table 5**

Flowering variability by family and microsite at 3.0 years for Mt. Pine Ridge plus-tree progeny in Puerto Rico

<table>
<thead>
<tr>
<th>Family No.</th>
<th>Non-eroded site</th>
<th>Eroded site</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conelets</td>
<td>Catkins</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>51</td>
</tr>
<tr>
<td>7</td>
<td>22</td>
<td>26</td>
</tr>
<tr>
<td>10</td>
<td>33</td>
<td>11</td>
</tr>
<tr>
<td>17</td>
<td>28</td>
<td>21</td>
</tr>
<tr>
<td>19</td>
<td>39</td>
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<td>28</td>
<td>17</td>
<td>39</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>33</td>
<td>21</td>
<td>30</td>
</tr>
</tbody>
</table>

REFERENCES


Requests for any publications reviewed or noted below should be addressed to the appropriate publishers and not to the Association.


Perhaps surprisingly, this is a book which should be consulted by all foresters concerned with tree planting — especially in tropical, developing countries, where honey production can be a valuable source of food and rural earnings.

The authors (all of the International Bee Research Association — an organisation which is to beekeeping what the Commonwealth Forestry Institute is to forestry) have chosen from a preliminary list of 2569 species which are reported in agricultural literature to be a major source of honey somewhere in the world, 467 ‘main entry’ species. 452 of those are nectar producing plants and 15, honeydew producers. A further 196 species are listed as being of major importance, but insufficient data was found to justify their inclusion as main entries.

For each main entry, details are given — backed up by reference coding — of the plant: its description, distribution and ecology, economic and other uses, flowering period and nectar and/or honeydew flow, pollen and honey production and of the honey’s chemical composition and physical properties, including flavour, aroma and granulation. This information has been admirably condensed by means of abbreviations and codes, so that the average entry is less than a page long. The coding is well explained and the terms defined for the non-apiarist at the beginning of the Directory. Anyone consulting the work is well advised to spend 10 minutes familiarising himself with its intricacies.

The exciting thing from a forestry viewpoint is that of the 467 species detailed, 267 are woody perennials — reflecting the great importance of trees and shrubs in honey production. There are references from some 144 countries: Fiji to Finland, Netherlands to New Caledonia. Many of the main industrial plantation species tropical and temperate are listed: eg 42 species of Eucalyptus, Gmelina arborea, Cordia spp Picea abies, Castanea sativa, Salix spp. Also included are many of the species suitable for social and community forestry: eg Prosopis juliflora, Calliandra calothyrsus and several Acacia spp along with the lesser known species eg Gliricidia sepium, Parkinsonia aculeata, Pithecellobium dulce which have vast potential for planting in arid zones.

Given that often any one of a number of species may be planted to meet the objectives of a social forestry programme eg. fuelwood, the forester can now choose species which are also of value as bee fodder. With imaginative planting one could envisage an area containing several species which flower at different times of the year, thus leading to year-round honey flow. Section 7 of the Directory lists plants with special characteristics — eg. those which show drought or salt tolerance, those which present problems to beekeepers, or those which give honey of certain characteristics eg. high sucrose, high ash etc.

It is difficult to be critical of a book which as its authors point out is new in concepts, in contents and in method of preparation. There are gaps in the information — sometimes because data is simply unavailable, sometimes because it has been inaccessible. Here, foresters with a knowledge of particular species may be able to assist the authors. Perhaps a listing of widely planted exotic species which are known to be of no value as a source of honey could be included in a later edition. One wonders if, for example, the ubiquitous Leucaena leucocephala is not listed because the data is unavailable, inaccessible, or if the species simply has little or no value.

We should have liked an alphabetical listing of all the main entry species. In part the specialised listings of section 7 suffice — but it would be so much easier to scan one list rather than 7 — which may not even include the species anyway.

Robinia pseudacacia, the honey locust, is mispelt as ‘pseudacacia’ the three times it appears in the book. Apart from this small error, we found no other typographical, nomenclatural or factual errors. This thoroughness of editing reflects the thorough way in which the authors have approached this vast subject on a tight budget. Honey production, on the other hand is an activity
which can cost the small farmer virtually nothing. Nor need it compromise the principal management objectives of other activities.

C. E. Hughes and P. S. McCarter

[Ed. The authors used the incorrect spelling of "pseudacacia" as the ‘o’ is missed out in the Flora Europea which was their guide.]


There can be few foresters to whom the name Bitterlich is unfamiliar. Few indeed will be those who have never applied the principle of ‘relative measurement’ in assessing the basal area of a forest stand. However, the number that would be prepared to stand up and be counted among those prepared to explain exactly what the principle of relative measurement is and in what ways it has been applied in forest inventory throughout the world must be very few. The appeal of this book should therefore be wide. For the many the elegance of the original insight into the way counts of trees subtending given angles at a point can give a direct measurement of basal area per unit of ground area has always fascinated. Here we are given an explanation that will be more easily understood than many of the ‘explanations’ given in the literature. Understanding is helped by the clear presentation and careful editing by W. Finlayson. English readers gain from the fact that the book has been published in English and the problems of direct translation have been avoided.

The theory and the history of angle count sampling is interesting but these are not the main themes of the book. It rather brings together descriptions of all the practical applications of the single germ of theory that has been so ingeniously developed over nearly 40 years since the earliest reference in the bibliography — a paper by Bitterlich published in an Austrian journal in 1947. The main appeal of the book will therefore be to practising foresters who are wanting to extend their knowledge of tree measurement using point sampling techniques. Much of the work described here has only been available up to now in scattered papers in relatively inaccessible journals and languages. The synthesis is timely. With this account, angle count sampling receives formal recognition of its place in forest inventory, for determining stand and tree heights, diameters, basal area, volume and stand density; for assessing thinning needs, crown cover and used as an integral part of management inventories for predicting optimum yield.

The title indicates that the instrument called the relascope is only one application of the principle of angle count sampling (referred to throughout as ACS so we will be saddled with another acronym). After dealing with all the complexities of ‘methods’ associated with Hirata, Kitamura, Ueno, Minowa and several others that are news to some of us, it is good to see that the use of the thumb as a relascope is not despised. Detailed descriptions of all the instruments used for ACS are given from ‘cross-staff’ to the Telerelascope. A chapter on ‘Refinements to increase the accuracy of ACS’ is particularly valuable. A chapter on the application of the method in inventory work in various countries includes much from the Central European and Nordic countries and North America. The U.K. gets four lines. In spite of the early recognition of the importance of the new techniques by Hummel and Keen (his article on the ‘Relascope’ in this Review appeared in 1950) it has not been as widely used as it might have been. Let us hope that with the publication of this book and its wide acquisition by readers of this Review this apparent lack of appreciation will be rectified.

P.G.A.


The first edition of the book was published in 1975 but it has been out of print since 1982. When given this second edition to review, I went to the forestry library at the Commonwealth Forestry Institute to take out the first edition, only to find that both copies had been withdrawn for repairs
to the binding. Demand and usage justly indicate the value of this outstanding work.

Tim Whitmore spent 17 years working on the forest botany of south-east Asia and the Pacific Islands before writing the first edition in which he managed to synthesize in a single volume the whole array of topics which concern the tropical rain-forests of south-east Asia. He is now a member of the Unit of Tropical Silviculture in the Department of Forestry, University of Oxford.

By the author's own definition, the book is written for people without a specialist training in biology as well as for the expert. Therefore, unnecessarily technical language is avoided and unfamiliar terms are defined. Nevertheless, it is, as John Wyatt-Smith points out in his foreword, an authoritative and masterly work in anybody's reckoning.

In its second edition, the book has been almost entirely rewritten and barely a page remains unaltered. Results of new research have been incorporated and the number of references given nearly doubled to 1140. The major new topics include the ecology of animals, an expanded account of silvicultural practice and the rationale behind the polycyclic system. A whole new chapter is devoted to nutrient cycling in the forest and perhaps this is the most significant addition. Despite immense technical difficulties in studying this subject, the author is able to present evidence to show that although there may be little leakage from main rain-forest ecosystems, it is certainly not always true that nutrients are held in the biomass - a large proportion is held in the forest floor and soil. It is necessary, therefore, to look elsewhere for an explanation to account for crop failure after forest clearance. Disruption of the forest floor causes serious damage to the nutrient economy. The effects of extraction equipment and subsequent agricultural practice are critical. One surprising fact, however, which should be of concern is the very high proportion of inorganic nutrients which is contained in the boles of large trees - over 50% of the within-tree total for all five main elements, N, P, K, Ca and Mg. There is an urgent need to gain a better understanding of the nutrient economy of the secondary forest and interesting evidence is put forward suggesting that some pioneering species are more efficient than others in restoring leached inorganic nutrients from depth to the surface layers.

This book contains a vast amount of information in a very accessible form. It draws together the results of research in many fields and the author has made it a fascinating story despite the complexity of the subject.

The book is fully and very well illustrated with photographs, figures and tables which have expanded captions for this edition. The double column format, the large clear pint and the page headings and chapter and section numbers at the top of each page, make it very easy to use for reference. The species and general index are comprehensive although I would have found it easier if page rather than just section numbers had been used.

The last chapter of the book is an excellent essay on trends in forestry and global awareness of the significance of the tropical forest. It makes a most eloquent and persuasive case for the conservation of the tropical rain forest.

Too many authors, and particularly those writing on ecological subjects, use a "barren superfluity of words" and it is refreshing to find such clarity and conciseness in Dr. Whitmore's book. There will be very many people who would like to buy the book but it is expensive and it is to be hoped that the publishers will soon consider producing it in a cheaper softcover edition to satisfy this need.

R. D. Barnes.


This is a book of some 200 pages, reproduced from typescript, about the French forest service in the nineteenth century, mainly from the point of view of sociology. Towards the end of the twentieth century French forests, forestry and foresters present a remarkable picture, and this account, even if parts of it need to be taken with large pinches of salt, helps to explain how things got to where they are now. Many of the issues it raises are acutely relevant to forestry in other countries at the present day: in western Europe, how to conserve the forest in spite of market forces; in the developing third world, the role of the state in combating deforestation.
The first chapter is a fairly straightforward, if somewhat long-winded summary of the history of the forest administration against the turbulent background of French nineteenth century politics, beginning with the reorganization of 1820, the opening of the Nancy school in 1824, and the Code Forestier of 1827. The key part played by Nancy is made clear. It not only built up the theoretical basis of forest management and silviculture, largely on German foundations, but also created the quite extraordinary 'esprit de corps' (for better and for worse) and is credited with the moral reform of the service — bribery and corruption largely went out as the new professionals from Nancy took over. The second chapter is an interesting digression into the creation and early history of many of the clubs and associations that influenced public opinion in favour of forestry in the years before and after 1900, some with names apparently unconnected with our subject, such as 'La Loire navigable' (and indeed in this case, the real connection is slight). Chapter III takes up the question of forestry as a career, and presents some interesting statistics on social origins and the like. Chapter IV breaks new ground: it tries to analyse the obituary notices of the period to find out, not so much what their subjects were really like, as what kind of men the establishment thought forest officers should be. A relatively short fifth chapter rather similarly (but based on 'a more accurate picture of the reality') dips into a small sample of the official dossiers that have been preserved, concerning the affairs of individual members of the service. Finally and inevitably the authors refer briefly to the present state of forestry and the forest service in France, and ask, in effect, what bearing their studies have on the most recent upheavals, dating from the reforms of 1964, and on the great changes that are going on in policy, administration, training, and perhaps most of all in economic and social attitudes.

W. Finlayson

**RESEARCH NOTES**

_Sampling Errors in Extensive Forest Inventory (Dr. H. C. Dawkins)_

Some years ago Dr. H. C. Dawkins suggested that sampling errors in forest sampling, even of continuous variables such as basal area and volume, could to some extent be predicted by the Poisson distribution (Dawkins 1971). A nomogram for this approximation appears in the _Commonwealth Forestry Handbook_ of 1981 on p. 160.

However it was early noted that the slope of the line by which sampling error per cent (E%) falls off with increasing stand density is less steep in practice than in theory. In short, E% will generally be underestimated by the theory, as would be expected if crop density tends to zoning or clustering rather than random dispersion.

The following argument, generated by some results observed in Nigerian inventories, suggests the use that can be made of this relationship.

1. By the Poisson hypothesis, for randomly distributed trees averaging m stems per plot (or transect), in a sample of n such plots:
   \[ SE_m = \sqrt{m/n} \]
   \[ E_{m} = \frac{100 x t x m^{-5} / n^{-5}}{m} \]
   \[ E_{m} = \frac{100 x t}{m (n^{-5})} \]

2. But
   - trees are seldom randomly distributed,
   - variance usually exceeds mean,
   - power of m in equation (2) is usually less than 0.5.

3. _And_
   - Over a large inventory, the greater the value of n, the more types of forest are likely to be encountered, especially if the inventory extends over greater areas. So, greater n will usually lead to greater variance,
   - power of n in equation (2), like that of m, will generally be less than 0.5.
   \[ E_{n} = \frac{100 x t}{n^{-5}} \]
In practice, unless the inventory is very limited (in which case useful generalizations are unlikely) the term 100 x t can be replaced to give:

$$E\% = \frac{K}{(m \cdot 5)}$$

where \( K = 200 \) ................................. (4)

In the case of the Nigerian “Indicative Inventory” (of 1977–9), sampling errors for numerous species assemblages were found to follow very nearly the following equation:

$$E\% = \frac{275}{V^{32} \times A^{42}}$$

where \( V \) = mean volume per hectare, analogous with \( m \) for stems/hectare.

\( A = \) area of forest sampled, at a constant sampling fraction and therefore analogous with \( n \).

In case of several inventories analysed in this Department over the past twenty years, the following relationship has been found to be surprisingly reliable:

$$E\% = \frac{K_1}{(m \cdot n)^{0.4}}$$

which is consistent in trend with the above argument.

And since both \( V \times A \) and \( m \times n \) are expressions of the total population within the sampling plots, it seems that sampling errors and numbers and sizes of sample units may all be related by the simple equation:

$$E\% = \frac{K}{T^b}$$

where: \( K \) is over 200 but has seldom been more than 250,

\( T \) is total number of stems or volume or basal-area observed,

\( b \) is coefficient less than 0.5 but rarely less than 0.4

Thus the slopes of the lines in the *Handbook* need only be reduced from a slope of \(-0.5\) to \(-0.4\), to produce likely general trends for sampling errors, relating all the parameters in equations (5) and (6).

Just for information, each line must cut the abscissa value of 1.0 when \( E\% \) is exactly \((100 \times t) \sqrt{n}\). The abscissa itself may be re-scaled for basal-area or volume when some field information on any plot sizes or stand densities become available.

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Paper in: The scientific management of animal and plant communities, 33–44.


*Commonwealth Forestry Handbook* (1981). Published by CFA, c/o CFI, South Parks Road, Oxford. (£6.00).

**Liquidambar styraciflua** — A further note by C. E. Hughes and P. S. McCarter.

Since publication of the paper on “*Liquidambar styraciflua* – a species of potential for the tropics” in the September 1984 issue of the *Review* (McCarter and Hughes, 1984) we have received reports of two new and exciting occurrences of *Liquidambar styraciflua* in Middle America. Firstly Mr Alan Lamb was able to report its occurrence in Belize. During his time as Conservator in British Honduras (now Belize) Mr Lamb discovered *Liquidambar* growing in one of the remotest parts of the country in the Maya Mountains close to the border with Guatemala at an elevation of around 600 m. The obliteration of the old chicle trail across the Maya Mountains from Cayo to
Punta Gorda due to windblow and creeper growth caused by the 1961 hurricane made access to the area difficult and it remains so even today. The second report came from Mr Earle Hindley who previously worked on FAO forest inventory projects in Central America and Mexico. Mr Hindley was able to report a substantial extension to our reported distribution into north-west Mexico. During surveys in Chihuahua State small pockets of 20 to 30 m tall *Liquidambar* were frequently found in shady streamside locations between 1200 and 1800 m. This places the northern limit for the species in Mexico at 30°N or more. It seems likely that similar occurrences may be found south into Durango State.

Both these reports are of considerable interest in terms of genetic variation. The Belize population matches the lower elevation limit for the species in the tropics in eastern Honduras while the Chihuahua populations are extremely isolated by tracts of arid scrub forest from the nearest known occurrences in eastern Mexico and experience frost and snowfall from October to April, possibly making them more closely related to the US populations.

The authors are extremely grateful to both Mr Lamb and Mr Hindley for their contributions towards completing this distribution map.

Efforts will be made during future collecting expeditions by CFI officers to visit these areas to collect herbarium and other material.

**REFERENCES**


**Actinomycetes antagonistic to *Phytophthora cinnamomi***

Dr. Luciano Gerrettson- Cornell, Senior Research Officer, Forest Pathology of the Forestry Commission of New South Wales, writing in *Forest and Timber* Vol 19 No 3, reports on some of the Australian work on the group of Actinomycetes. These micro-organisms are now considered to be bacteria, although the single cells can produce ‘threads’ similar to various fungi, suggesting that they might be an intermediate form between the two. They are able to use substrates for growth which can not be processed by bacteria or fungi. Whilst some actinomycetes can be pathogenic to plants and animals it is their antibiotic potential which has attracted the interest of researchers. The Wood Technology and Forest Research Division of the Forestry Commission of New South Wales commenced long term work on actinomycetes in 1979. Particular attention was paid to the two genera of *Streptomyces* and *Streptovercillium*; a satisfactory computer programme has identified 465 species of *Streptomyces* described by participants in the International Streptomyces Project. Laboratory culture experiments assessing actinomycetes antagonistic to root rotting and damping off fungi of various species of *Pythium* and *Phytophthora* showed that half of the representative strains of 15 groups of *Streptomyces* from the root zone of *Casuarina littoralis* from native forest were strongly antagonistic to *Phytophthora cinnamomi*. ‘Damping off’ can cause the destruction of a seedling crop, the fungi attacking as the plumule passes through the soil. *Casuarina* species are usually resistant to *Phytophthora*. The suggestion is that this resistance may be associated with the action of the actinomycetes antagonistic to the fungi and that the responsible micro-organisms can be cultured and used in place of the chemicals currently employed to protect nursery stock.

**Trees and Salt**

An annotated bibliography compiled by J. Fraser of the Commonwealth Forestry Bureau is C A B publication F 33 : ISBN 0 85198 5270. An alphabetical index of authors, lists 349 names with reference numbers leading to 228 abstracts which are again in alphabetical order of author but sub-divided into four main sections. There are 31 abstracts on ‘Laboratory studies of tolerance and physiology’, 89 references to ‘saline soils’, 32 on ‘Coastal salt spray and flooding’ – 9 of which specifically mention ‘mangroves’ and 73 on the adverse effects of ‘road de-icing salt’.

Increasing concentrations of salt (sodium chloride) progressively add to the problems of trees suffering from diminishing availability of moisture. An article by S.H. Bangash in the *Pakistan Journal of Forestry* showed that seed and seedling tolerance for salt was greater for *Acacia arabica*, *Albizia lebbek* and *Ziziphus jujuba* than *Parkinsonia aculeata*, *Prosopis spicigera* and
Robinia pseudoacacia. Australian Forest Research, 1981 mentions work by T. J. Blake in which 52 different eucalypts were assessed for salt tolerance as seedlings. The following were considered of high tolerance: Eucalyptus woodwardii, E. tereticornis, E. camaldulensis, E. calophylla, E. erythrocorys, E. largiflorens, E. incrassata, E. neglecta E. globulus ssp. globulus and E. lehmannii. It is recorded by T. C. Gates in the Australian Journal of Botany, 1972. 20.3 that Acacia harpophylla and Atriplex nummularia could tolerate saline concentrations up to and beyond that of sea water. Trial plantings in the dry, saline, cold and windy steppes show promising results with Ailanthus altissima. This work is recorded by A. V. Zelenin in Lesnoe Khozyaistvo, 1976. 9. Although unseasonal frosts caused damage, the trees withstood −33°C and reached an acceptable 6 to 8 m in 16 years.

Many individual papers refer to tolerance trials for a limited range of species but the bibliography includes books such as ‘Dry lands: man and plants’ by R. Adams et al (Architectural Press Ltd. London, 1978) which in turn has 74 references. A paper by N. Saleh-Rastin in the European Journal of Forest Pathology 1976, 6, 3 has the title ‘Salt tolerance of the mycorrhizal fungus Cenococcum graniforme...’ This drought resistant fungi could, in liquid culture, tolerate salt concentrations of 11 g Na Cl/litre, the order of salinity encountered in ‘most salty soils in dry regions is 6 to 8 g/litre.’ Plants forming mycorrhizal associations with this fungi may benefit with increased drought resistance.

Whilst planters in temperate lands are encouraged to incorporate as much friable surface soil as possible around the roots of the young tree and appreciate that some deficient soils require the addition of minerals, the planter in arid regions need to remove the salt laden surface soil and can benefit the young tree by adding a buffer which takes minerals out of circulation.
THE REVIEW

INSTRUCTIONS TO CONTRIBUTORS

The Association's REVIEW is published quarterly in March, June, September and December. It is a medium for the exchange of information on forestry in all its aspects among foresters of the Commonwealth and of other countries, particularly in the tropics and sub-tropics. Its contents include scientific, technological and descriptive articles, technical and other notes and reviews of current forest literature. Contributions are invited from members and others.

CONTRIBUTIONS. Articles should be of wide interest, or review or propound advances of theory or technique of application outside the area of origin.

The Review should not be regarded as a depository for information of purely local interest; such cannot be accepted.

Articles should be clearly typed in double spacing on one side of A4 paper, leaving a left hand margin of at least 2.5 cm. Ideal length about 3000 words, maximum 4000.

SUMMARY. Each article should be preceded by a summary which should be an informative precis of the contribution, indicating the main facts and conclusions, and not merely a description of the paper. In length it should not exceed three per cent of the original and in most cases less should suffice. It is assumed that authors waive any copyright or translation rights in such summaries.

ILLUSTRATIONS, TABLES, STATISTICS, etc. Tables are expensive to print and should be kept to a minimum. For most readers there are often far too many digits; 356 ± 15 means just as much as 356.24 ± 15.15, provided the nature of the confidence limits is defined. An asterisk* for significance tests means the same as 0.05 > P > 0.01. Histograms or Graphs convey more to the average reader than tables. This may be more work for the author but our main concern is for the reader; if appropriate figures are wanted they can be read off the diagram; precise figures can be obtained from the author.

Histograms or Graphs should be on a scale which allows for reduction to half original size. Lettering and symbols should be typed, stencilled or written to be clearly legible in anticipation of reduction to half size; standard size type is the smallest which can be accepted. Care should be taken that lettering and symbols are correct, and that they agree with both the legend and the text.

Captions must be provided for all illustrations; they should be typed on a separate sheet of paper and clearly numbered to correspond with the appropriate illustration, etc.

Half tone blocks (from photographs, etc.) are expensive; normally, only two plates can be accepted per paper. If an author wishes to include more, he may be asked to pay for them.

REFERENCES. The name of the author and the year of publication should be cited in the text; references should be listed at the end of the paper in alphabetical order of authors, and for any one author in chronological order. For books the title should be underlined (for printing in italics), e.g. EVANS, D. J. (1982) Plantation Forestry in the Tropics. Oxford University Press. For papers in journals, bulletins, etc. in series, the name of the journal or series should be underlined and both first and last pages should be given, e.g. TEO, P.C. (1966) Revision of Royalty Rates. Malayan Forester 29(4). 254-8. If a work is unpublished (e.g. a thesis), the fact should be stated.

OFFPRINTS. Ten copies of all articles published are issued free to contributors. When the copy goes to the printers, authors will be informed in which number the article will appear. The cost of additional copies (photo) will be notified at the time and any required should be ordered then paid for in advance.
Commonwealth Professional Association: Award for Innovation

Members are reminded that there will be two awards for 1985 worth £2,000 each. Applicants should forward details of their scheme which should be applying an original idea — under the heading of technology or communication — for the sustained benefit of one of the developing Commonwealth countries. These details should reach the Secretary of the CFA by 1 November, 1985. Surely some member can take a simple observation and conceive of a novel application. Boucherie noted that sap would run from a tilted pole, he placed his tank of copper salts on the higher end and made a name in the preservation world. We now see poles of spruce, which is a species reluctant to receive chemical treatment, receiving a suction on one end whilst the other end and surrounding timber is subjected to fluid preservative under pressure. Once the salts are drawn through the sapwood, there is sufficient chemical retained to discourage fungal and insect attack. It is a simple step to the next application of the idea to the Channel Tunnel. There is merit in keeping the diameter to the minimum to accommodate the train, but there now needs to be sufficient energy to push the column of air the length of the tunnel; even half way across, the partial vacuum behind the train exerts considerable drag. The twin tunnels of the CFA design (using quantities of marine plywood) have both English and both French ends joined with 'Bonjourcherie' baffles. Trains will start each side at the same time, allowing for 'summer time', the air being rammed forward by each train will help propel the other. It is likely that the principle will be given a German name, once the most appropriate prefix for 'speed' has been identified.

Commonwealth Foundation Fellowship Scheme

The 12 Fellows who arrived in London on 15 April at the start of their month in the UK included Tony Cannon, Chief Forester for Forest Resources of Tasmania, nominated by the Commonwealth Forestry Association. The intensive programme of meetings, visits and home hospitality had three days set aside for Fellows to pursue their own subjects. Mr. Cannon visited the Forestry Commission Research Station at Alice Holt, the Crown Estates at Windsor and, with the Association's Secretary, the Commission's forest enterprise at Brandon and Thetford Chase. At the conclusion of the month, Mr. Cannon visited the Economic Forestry plantations in Eskdalemuir in South West Scotland and some of the eucalyptus plantations in France. The Association has the opportunity of forwarding two nominations for the 1986 Fellowships from nationals of Barbados, Brunei and Ghana. Suggestions should have reached the Secretary, CFA, by 20 November, 1985. The forestry nominations for the subsequent year will be from Belize, Dominica and Kiribati.

Annual General Meeting

The opportunity for a meeting in Scotland encouraged the Association to develop the event over two days. The AGM was held before lunch on 18 April, following morning meetings of the Executive and Governing Council. The venue was Bush House at the
Edinburgh Centre of Rural Economy at Penicuik. Our President, His Grace the Duke of Buccleuch and Queensberry, K.T. congratulated Dr. J. D. Brazier on his three years of stewardship as Chairman. The year had started on a high note with the meeting at Cumberland Lodge and the visit to the Valley Gardens in Windsor Great Park. Although the hosts for our proposed Autumn meeting suffered a last minute change of plan, we were to be invited to visit their furniture factory at the next suitable opportunity. The numbers of members had increased in each of the four classes and we had once again passed the thousand mark; it was particularly pleasing to see so many at an AGM with special welcome to Peter Banks from Zimbabwe and Dr. Moulds from Australia. One sad note was that our Assistant Secretary, Judy Bromiley, was planning to retire during the summer after seven years of cheerful and diligent service on the Association’s behalf. His Grace presented Norman Weiss with a cheque for £150 and the Tom Gill Medal for his winning essay ‘Forestry Investment — ‘Should I do a planting Scheme?’ — a case for Lowland Broadleaves.’ One change during the year was that the Executive Committee had asked one of the committee — J. S. McBride — to take over the organisation of the Review’s advertising; his application and enthusiasm was already producing results as was manifest in the March issue. Appreciation was also expressed to other members who made time available on behalf of the Association, for those on the editorial committee, our reviewers, our honorary treasurer, Pat Hardcastle and to Dick Willan for his services as Auditor. A welcome was offered to the incoming Chairman Dr. M. E. D. Poore and Vice-Chairman D. L. McNeil.

During the lunch, we had as guests several of those who would host subsequent parts of the meeting. Prof. Fred Last gave us the background to the Institute of Terrestrial Ecology with its eight stations around the country under the Natural Environment Research Council, Dr. Mike Unsworth explained how the station at the Bush Estate was developing as a centre for a number of various disciplines and expressed the hope that they would soon be joined by Freshwater Ecology, whilst Dr. Roger Leakey outlined the research project in the vegetative propagation of West African Hardwoods which would be one of the afternoon visits.

The Institute of Terrestrial Ecology was established in 1973 by the merger of the research stations of the Nature Conservancy and the Institute of Tree Biology. The scope of the work could be considered under 15 broad headings, from plant and animal population dynamics to pollution and fresh water ecology. Successful research contracts had already been completed abroad on each of the continents. Members were shown work on mycorrhiza by Dr. Philip Mason and Dr. Julia Wilson. Nursery Managers should be aware that some of the fungus such as Amanita muscaria which form beneficial mycorrhiza with adult trees, may give indifferent colonisation with seedlings and that early survival might be enhanced by inoculation with a fungi such as Hebeloma sacchariolens. Dr. Lucy Sheppard, working with Forestry Commission material, was assessing in the laboratory, the timing and severity of frosts which might be withstood by a range of exotic conifer provenances. Photoperiodism triggered the termination of growth in clones of Sitka spruce as early as August. Cooling was also being used by Roger Leakey to stimulate flowering: roots were being cooled, whilst leaving the tops at 30°C. Several desirable tropical hardwoods have seeds which retain viability for very short periods. Obeche, Triplochiton scleroxylon, can remain viable for up to a month but will already be suffering from fungal attack and insect predation. Techniques have been developed for the vegetative propagation using single node leafy softwood cuttings. The cutting is kept in subdued light with plenty of red wavelength light, treated with rooting hormone. The rooting success after six weeks is 80–90%. Members enjoyed seeing young omu (Entandrophragma), opepe (Nauclea diderrichii) makoré (Tieghemella heckelii), Terminalia and Prosopis species in tropicalised glasshouses.
A dinner was held in the evening at the Cringletie House Hotel which is set in 20 acres of grounds in glorious isolation, north of Peebles. It was an occasion for some 28 members and wives to wish Judy Bromiley well. The Chairman presented a crystal decanter, suitably etched with the Association’s wishes and the logo.

On 19 April, David Seal welcomed members to the Forestry Commission’s Northern Research Station, this is also on the Bush Estate. Roy Faulkner demonstrated the comparative growth rates of various breeding trials and provenances of Sitka spruce (*Picea sitchensis*). Although the more northern and exposed seed origins might have less risk of damage from frost, the faster growth rates of some less hardy sources can more than compensate for the superficial damage, especially when trees have the opportunity to grow above the height of spring ground frosts. Bill Mason outlined the progress which had been achieved with the vegetative propagation of sitka spruce. The improvements which elite material can currently provide over the average performance of Queen Charlotte Island seed at 10 years of age is 10% in both height and diameter. Seeds with these improved characteristics will become available from seed orchards established in the mid ’70s, but not in bulk for a further 15 years. In the interim, it is possible to produce desirable progeny from hand pollination. These seedlings can be multiplied many times within five years for mass planting. Forestry Commission Note 90 84 SILN gives the recommended details. Juvenile stock plants, two years from seed, are raised in optimum enclosed conditions to produce a plant 75–100 mm tall. This can yield up to 100 cuttings, tip, base and intermediate. The Newton Nursery has produced about 85,000 rooted cuttings a year since 1982. Delamere and a private sector operation (Elite Trees) commenced operation in 1984 and by 1988 should produce 1 M plants annually. This is about 2% of the UK annual sitka planting requirement. The performance in the forest of this material of cutting origin compares favourably with traditional transplants and in one unreplicated plot established at Newcastleton in 1953, the cuttings are outperforming the transplants. At least 20 unrelated families are being used for stock plants which should ensure the maintenance of genetic diversity. Another species for which there is inadequate seed is hybrid larch (*Larix eurolepsis*). Less than 20% of the quantity of the desirable F 1 cross can be obtained. Forestry Commission work on larch vegetative propagation is published in *Research Information Note* 91 84 SILN. Softwood cuttings from juvenile stock, two years from seed, could be rooted with 80–90% success with tip material but loss of turgor resulted in plants with bowed stems. The short period of growing season remaining after rooting is a disadvantage. Hardwood cuttings taken between February and April were being rooted with the same percentage of success and it was hoped that this would provide the basis of a commercial system. Work is also being undertaken with *Pinus contorta* and other conifers.

The Annual Address to the Association on ‘The UK Timber Industry’ was presented by Roger Bradley, Divisional Head of Harvesting and Marketing. Part of the paper will feature in the 12th Commonwealth Conference and coverage in the *Review* will be delayed until the September ’85 issue.

After lunch, attended by 42 members and friends, our President kindly hosted the meeting on his estate at Dalkeith. The land, to the south east of Edinburgh, straddles the confluence of the North and South Esk. The 230 ha of managed woodland grows on fertile drift soils at elevations between 20 m and 120 m enjoying a rainfall of 710 mm, a growing season of 230 days with some protection from exposure afforded by the Pentland Hills. Highlights of the tour included demonstrations of squirrel control in a fine stand of beech, the use of a Trekkasaw converter which had reduced the production costs for firewood from £10.87/T down to £5.18/T. The Old Oak Wood, which the Estate has continued to cherish since the report of 1793 suggested some trees were over 250 years, still has many trees which were well established at that time. In 1972 the 19 ha
area was designated a Site of Special Scientific Interest which, with the constraints imposed, renders the chances of oak over 200 years old being seen in 2193 considerably reduced. Other broadleaves noted were sycamore, sweet chestnut, ash and *Nothofagus* with conifer plantations of European, Japanese and hybrid larch with both *Tsuga* and *Abies grandis* planted as understory. The Earl of Dalkeith assisted the Chairman with the planting of a commemorative tree and in the Adventure Playground — which has
attracted over 120,000 during the last three years — he demonstrated the aerial ropeway. Members concluded their visit with tea before a roaring log fire in the Great Hall of Dalkeith House, part of which includes the remains of the 12th century castle. The external warmth generated by the hospitality was enriched with a parting dram which was still helping the Secretary on his way home some seven hours later and 300 miles south, loading container conifers ready for a client’s collection later in the morning.

**Membership Fees**

With regret, the Executive Committee recommended to the Annual General Meeting that as a result of the printing and postage costs for the *Review* having risen since the membership fees were last revised in 1981, the following subscription rates should come into effect from 1 January, 1986.

- **Ordinary** (An individual up to the age of 30 years) £10.00 p.a.
- (An individual of 30 years or more) £15.00 p.a.
- **Associate** (Students or VSO equivalents) £5.00 p.a.
- **Affiliate** (Forest Departments, Firms and organisations) £30.00 p.a.
- **Libraries and Casual sales** £30.00 p.a.
- **Life**
  - (After 30 consecutive years of membership) £250.00
  - (For those over 60 years, having paid 10 consecutive years) £50.00
- **The Commonwealth Forestry Handbook (10th Ed.)** £6.00 plus p/p

Members are reminded of the benefits which the Association can derive from Covenants. The 78 members who had covenants in ’83–’84 brought in an additional £330 from the Tax Authorities.

**The Autumn Meeting of the Association at Victoria, Vancouver Island**

On Wednesday 18 September, 1985, there will be a business meeting at 6 p.m. in the Empress Hotel, Victoria with the chair being taken by Vice-President Christopher Latham.

On Thursday 19 September, 1985, the Association will host a reception at 8 p.m. at the Oak Bay Beach Hotel. It is encouraging to record that we have already heard of 30 members who will be attending the Conference. Further information on these meetings will be on the Association’s static display in the Empress Hotel. Details of the Conference appear in the last five issues of the *Review*, in particular pp. 153–156 of September, 1984. The Secretary-General, Cliff Brown, Canadian Forestry Service, 506 W. Burnside Road, Victoria, B.C., Canada has the up-to-date details including the names of participants.

**Multi-disciplinary Seminar: Tanzania, October 1986**

A six-day seminar is planned for the middle of October 1986 based on Arusha in Tanzania. Six Commonwealth Professional Associations will co-operate with the Commonwealth SADCC countries (Botswana, Lesotho, Malawi, Swaziland, Tanzania, Zambia and Zimbabwe, plus Kenya and Uganda). Angola and Mozambique may be invited as
observers. The foresters will have an opportunity to contribute to the discussion under four headings: Fuel and Energy — biomass, wood and charcoal; Watershed Management; Agroforestry; Forestry — trees in the environment, conservation and improvement of soil and natural habitat and a final session with possibly two speakers on the growing of trees as a source of raw material for industry. It is hoped that the speakers will be from a range of the participating countries with some representatives of outside agencies such as UN/ECA, Habitat, the World Bank and the African Development Bank. Support for the seminar is being elicited from the Commonwealth Foundation. The Secretary will be replying to Local Honorary Secretaries who have already suggested speakers but further names would still be welcome.

The Noma Award

The award was established in 1979 by Shoichi Noma, founder of the Japanese publishing firm of Kodansha Ltd. The Managing Committee, under the chairmanship of Professor Eldred Jones, University of Sierra Leone, selects their assessment of the best book written by an African and published in Africa. This year’s winner was the late Bernard Nanga a Camerounian, the title was La Trahison de Marianne. The $3,000 prize will be presented to a representative of Bernard Nanga’s family at Dakar in December. Further details of the award may be obtained from Hans Zell Publishers, 14 St. Giles, P.O. Box 56, Oxford OX1 3EL.

British Executive Service Overseas

Incorporated in 1972, BESO is an independent voluntary organisation funded by government through the ODA, by industry, commerce and charity. Retired business executives with professional, technical or specialised management skills are called upon to help developing countries achieve economic independence, self-sustaining growth and an improved standard of living. The average duration of an assignment is 2–3 months. BESO makes the air travel arrangements and meets the full cost for both the executive and spouse. There is no fee or salary. The host country or organisation is required to provide suitable accommodation, subsistence and transport. As many as 130 assignments are made each year to 60 different countries. In Guyana, Demerara Woods Ltd., is funded by the World Bank and EDF. Mr. J. P. Law helped as a Mechanical Engineer, Mr. H. C. Tapley, whose career was with the Forestry Commission, has had two engineering assignments and Mr. A. Whayman, also ex Forestry Commission spent two months helping with the engineering side of the logging operations with extraction rates reaching 9,000 m³ a month. Further details may be obtained from BESO, 10 Belgrave Square, London SW1X 8PH.

Corrections

Our apologies to the authors of the ‘Effects of Resin Extraction on Optically determined Density of Pinus caribaea Morelet and P. oocarpa Schiede’ which appeared in the March, 1985 issue of the Review 64(1) No. 198, 1985. The formula on page 30 should be:
Two other alterations are also required to the Research Note by Dr. H. C. Dawkins on page 78 of 64(1) No. 198, 1985:

Equation (1), (2) \[ E\% = \frac{(100 \times t)}{(m^5 \times n)} \]

should be \[ E\% = \frac{(100 \times t)}{(m^5 \times n^5)} \]

and the ultimate paragraph should read:

'Just for information, each line must cut the abscissa value of 1.0 when E\% is exactly \((100 \times t)/\sqrt{n}\). The abscissa itself may be re-scaled for basal-area or volume when some field information on any plot sizes or stand densities become available.'

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When replying to this advertisement, please mention the Commonwealth Forestry Review.
To all members of the Association

Dear Member

Some of you will not be aware that on Thursday 18th April, after a dinner held at the Cringletie House Hotel near Peebles, I was given a lovely decanter as a leaving present. The Association Chairman, Dr. John Brazier, presented it to me and I am extremely grateful to him and to everyone who went to so much trouble to have the decanter beautifully engraved with the CFA logo as well as my name.

I would like to say that my seven years with the CFA have been very happy ones and I will always look back on my association with the world of forestry with grateful thanks for a very interesting and worthwhile time.

With kind regards and best wishes to you all

Judy Bromiley
Assistant Secretary

The Editor
The Commonwealth Forestry Review

85-02-08

Dear Editor

Eckmüller, Madas and Sustained Yield

The book “Forest policy, a contribution to resource development” edited by F. C. Hummel, was reviewed in No. 196. Although the reviewer, E. G. Richards, praised the text without reservations, I would like to make a critical remark on one particular section of the book. In a chapter called “The production functions” Otto Eckmüller and András Madas, among other things also write about sustained yield forestry.

In a book on forest policy, the concept of sustained yield is necessarily included. One should, however, expect a more scientific treatment when the authors are two experienced professors like Eckmüller and Madas. As the text is formulated, it is mainly a defence of the myth of sustained yield, rather than a rational discussion of various options in felling policy. They start their section on the principle of sustained yield (p. 86) by stating:

“One of the most fundamental principles of forest policy must be that forests should be managed in a way which will maintain and where practicable, improve the productive capacity of the site and the forest”.

I agree that this has been, de facto, one of the most fundamental principles of modern, European forest policy, although it has not always been practised. That is why it is
necessary to discuss the subject. But why does sustained yield *have* to be a fundamental principle? Eckmüller and Madas do not give any justification for their statement. They just continue saying that

"management should seek to prevent too great fluctuations in the level of annual or periodic fellings . . . the amount of wood removed in a, say, ten year period, should not surpass the *allowable* cut for that period."

These are all normative statements, and the reasons why are never discussed. Their unconditioned proposition that "the principle of sustained yield and an allowable or potential cut should, *of course* be applied to a country's forestry as whole also", is straightforward erroneous.

Sustained yield may be a reasonable policy for a firm, or forest owner, restricted to forest production and with little knowledge on alternative capital investments, but from a country's point of view many options of capital investments are open for consideration. The transfer of capital from forests to other sectors by high fellings surpassing the so-called (by whom?) allowable cut, may be highly rational if more profitable investments are available and lack of funding is felt as a restriction. This is especially the case when the forests contain large proportions of old and slow growing stands. The same argument may be used in case of individual forest firms if they are ready to enter into other businesses.

And here we are at the centre of Pressler's theory of "money yield" as opposed to the earlier concept of "forest yield". Pressler demands of forestry that it yields as much in money terms as any other economic activity. Most elegantly this is formulated in Faustmann's formula which states that a forest stand should be felled when its marginal rate of return falls below the rate of discount. And the rate of discount can be understood as the opportunity cost of capital. Faustmann's formula is obviously correct for one individual stand, but if it is practised rigorously in a forest structured differently from the so-called "normal" forest, the volume of fellings and consequently the economic result, will vary considerably over time if the rate of discount is maintained. This may not be correct if investment opportunities vary from one planning period to another. Therefore, an economically optimal time path of fellings may be rather complicated to calculate. Lyon and Sedjo (1983) have, however, shown how the long-term supply of timber from a forest region is likely to develop if the actors behave economically rational. Based on a chosen age structure of the forest, their example diverges greatly from the sustained yield option.

From the society's point of view, Faustmann's formula is obviously too simple. It takes the price of timber as given. When discussing a felling policy of a country, the volumes involved are so large that the price will be affected. Optimal time paths of fellings in a social context, must therefore be determined in less elegant, but more comprehensive ways. Hultkrantz (1982) has tried to do so for Sweden, and nothing indicates that a non-decreasing volume of fellings, as advocated by Eckmüller and Madas, is necessarily the best option.

The economic cost and benefits of various paths of fellings are not discussed by Eckmüller and Madas. They rather make the principle of sustained yield a moral obligation. This is the same position as taken by Moiseev & Sinitsin (1981) at the 17th IUFRO World Congress. One should have thought that Klemperer's (1981) arguments at the same event would have had some influence on how sustained yield is discussed later. I do not demand from Eckmüller and Madas that they agree with Klemperer's economic arguments, but they cannot be totally overlooked. The question whether their contribution to the book is to be seen as one policy statement as opposed to many others, becomes quite justified. I would for myself, have preferred a discussion of the many,
equally rational, options available, rather than Eckmüllner and Madas own personal opinion. Nor can I imagine that they themselves wanted to formulate the felling policy of world forestry.

References


Yours truly
Ole Hofstad

Research Branch
Ministry of Forests
1450 Government Street
Victoria, B.C.
V8W 3E7 Canada

24 January, 1985

Dear Sir,

Given the burgeoning number of articles on SPR since its inception in 1942, and the apparently limited application of this sampling technique in forestry, the review by Matis, et al. vol. 196 (1984) was pertinent and timely. The authors, however, fell short of their intended task of providing "a comprehensive review of the literature (on SPR)". The compiled bibliography was incomplete, assuming a review period from 1942 to 1983. Over forty published articles, most of which are available in statistical or forestry literature, were omitted. (The editor has 49 references for interested readers.)

In particular, the authors failed to refer to the bulk of literature extending SPR theory (based on the simple random sampling design) to other designs or techniques such as stratified sampling, multistage sampling, double sampling for stratification, ratio estimation, variable probability sampling, and time series analysis. More importantly, many of the forestry oriented articles concerning relevant subjects such as sample size determination in SPR were, unfortunately, not included in the review. Furthermore, with much of the literature on SPR apparently not reviewed, it is surprising and perhaps misleading that the authors conclude "It seems from the literature that theoretical investigations and extensions of the available theory to new fields of forest practice have almost been exhausted". To the contrary, much work needs to be done especially in simplifying the apparently complex theory and assumptions required in SPR.

For completeness sake, I have compiled in the bibliography most of the articles, omitted in Matis, et al. (1984), dealing mainly with SPR theory. Perhaps a thorough critical review of the theory and applications of SPR to forestry would be more useful.

Yours faithfully

S. A. Y. Omule
Correspondence

University College of North Wales
Department of Forestry and Wood Science
Bangor
Gwynedd LL57 2UW UK

The Editor
Commonwealth Forestry Review

24 April, 1985

Dear Sir,

You have kindly offered us the opportunity to respond to the interesting comments made by Dr. Omule on our article entitled "Sampling with Partial Replacement — A Literature Review", published in your Journal in September 1984. We are most gratified that someone has bothered to read it. We also welcome the references in his list which post-date the preparation of the manuscript in 1981 on which the article was based.

Dr. Omule complains, however, that
1) the bibliography compiled was incomplete;
2) the article failed to deal with a number of extensions to the technique of SPR;
3) sample size determination was not discussed, and
4) the theoretical work is far from being at an end.

We would like to comment briefly on these points.

The article proposed to review the literature. "Comprehensive" was we agree perhaps too strong a word. A literature review, however, is not and does not set out to provide a complete Bibliography but to draw the attention of the reader to salient features of the subject and to provide key references. Our list of references was deliberately headed just that to avoid any confusion. Apparently to no avail. Even the additional references supplied by Dr. Omule do not turn the list of references into a Bibliography.

The extensions that Dr. Omule mentions all follow from the basic concepts of simple random sampling. They are such an essential part of forest inventory that unless SPR could be used with these techniques it would have little relevance to forestry. Furthermore they are largely covered in the list of references presented. In particular they are referred to by Ware and Cunia (1962) who also discuss the question of sample size at some length. Explicit reference could have been made to some of these extensions but in the interest of brevity these and many more specific examples of forestry applications were excluded. The mathematics associated with these extensions are, incidentally, quite horrific to the average forester and detailed consideration of them is usually only to be found in some of the more esoteric statistical journals.

It seems that, in fact, there is no disagreement between the writers and Dr. Omule on future studies in the field of SPR. Dr. Omule appeals for efforts "... in simplifying the apparently complex theory and assumptions required in SPR". We strongly support this statement but continue to aver that theoretical investigations and extensions of the available theory to new fields of forest practice may have almost been exhausted. Admittedly it is dangerous to be too dogmatic in such matters and so we await new developments with keen interest. The reader will forgive us, however, if we do not promise to hold our breath in anticipation at their appearance.

Yours faithfully,
K. G. Matis, J. C. Hetherington and J. Y. Kassab
Dr. John Dargavel, receives congratulations for his appointment as the first forester to be a Research Fellow in the Australian National University’s Centre for Resource and Environmental Studies.

Peter Drysdale, General Manager of the Fiji Pine Commission, is still assessing the damage caused on the 16 and 17 March, 1985 when wind speeds reached 180 mph.

M. B. D. Feika, has retired as Chief Conservator of Forests, Sierra Leone. He has been the Association’s Local Honorary Secretary since 1974. The incoming Chief Conservator is Mr. A. P. Koroma.

William Hartley, a winner of the Schlich Memorial Prize, has been growing his own Pinus patula, Eucalyptus grandis, Oranges, Pecan, Macadamia and Tung nuts for the last 20 years and is now assessing the UK prospects which might benefit from his sawmilling and forestry experience, part of the latter was gained with Alice Holt.

John Hook, who spent 6 years in Jamaica before a tour in the Seychelles, will be heading the forestry section for the Government of the Bahamas; one of the terms of reference being the management — on the basis of a sustained yield — of the Island’s pine forest. His address is: Department of Lands and Survey, Box N 592, Nassau, Bahamas.

Dr. John Howard, who is working with FAO, is Chief of the Remote Sensing Centre. The scope of this work includes agriculture and fisheries, as well as forestry.

Bob Izlar, Executive Vice President of the Mississippi Forestry Association Inc., our Local Honorary Secretary in the USA, receives congratulations on the birth of his son.

Sam Musa Jambawai hopes, with the help of the Commonwealth Foundation, to attend the 12th Commonwealth Conference in Victoria. He has been appointed Assistant Chief Conservator of Forests in Sierra Leone.

Frank Knight, Local Honorary Secretary in Zimbabwe, is now at Nyanga, P Bag 31, Juliasdale. He expresses appreciation for the overseas funding which is helping the Zimbabwe Forestry Commission with its transport problems.

Dr. R. Lawton retired from the ODA last July. He is a freelance consultant on Tropical Forest, Range Land and ecology. The end of 1984 was spent in Jordan and Tunisia and the early part of 1985 in Oman where he is the Minister of Agriculture and Fisheries’ forestry consultant.

M. J. Masilo has taken up the new post of Director of Conservation and Forestry in the Ministry of Agriculture and Marketing, Maseru, Lesotho.

Dr. Henry Osmaston, whilst sending his apologies for the AGM and, as have many other members, wishing Judy Bromiley well in her retirement, mentioned that his daughter was studying for her M.Sc. in Forestry at Edinburgh. F. C. Osmaston joined the Association in 1929; does the Association have other examples of third generation foresters?

P. D. Palmer is now Deputy Chief Conservator of Forests, Sierra Leone.

Marcus Robbins is working as ODA/TCO advisor to the EEC/ODA funded National Tree Seed Project for Nepal. He offers a welcome to members who might come within range of the British Embassy, Lainchur, Kathmandu.
Harald Schneider, ex Zambia, and Harold Malyon are both ex UK Forestry Commission and have founded ‘British Forest Surveys’. Their scope at present includes soil classification, terrain class, windthrow hazard, yield class, general mapping and inventory with the associated computer software to ease management. They can be contacted at Whisgills House, 29–30 Montagu St., Newcastleton, Roxburghshire, TD9 0QZ.

R. J. Streets expresses the enjoyment that just under 40 years of CFA membership has afforded him but reluctantly admits that his tree interest now has the confines of the grounds at Gotton Manor, Chale, Isle of Wight.

Jack Thirgood, Professor of International Forestry at the University of British Columbia, has been appointed to the editorial board of Reclamation and Revegetation Research, published by Elsevier of Amsterdam.

Deaths

HALL, W. T., CSI, CIE, late Chief Conservator of Forests, United Provinces. He joined the Association in 1924.  
SIMPFENDORFER, Kenneth J. c/o Forests Commission, Melbourne, V.C. 3001, Australia. He was our Local Honorary Secretary in Victoria and has been a member since 1958. His untimely death earlier this year was reported to the Association at the AGM in Scotland by Dr F. R. Moulds, who was over for the occasion. He will be sadly missed by us all and we send our condolences to his family and friends.

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MALIMBWI, R. E., c/o Dept. Forestry, University of Aberdeen, St Machar Drive, Old Aberdeen AB9 2UJ, UK
FORTHCOMING INTERNATIONAL DATES


5/8/85–10/8/85 BRAZIL, Curitiba: IUFRO (Gp S2.05-00) ‘Resistance of Trees to harmful agents’. Ref: K. von Weissenberg, Forest Research Institute, SF-77600 Suonenjoki, Finland or: J. H. Pedrosa-Macedo, Universidade Federal do Parana. P.O. Box 2959, 80 000 Curitiba PR Brazil.

19/8/85–22/8/85 CANADA, Laval University, Quebec: Biennial Conference of the Canadian Tree Improvement Association — theme ‘New Ways in Forest Genetics’. Ref: Dr. Armand Corriveau, Centre de Recherches Forestieres des Laurentide, CFS CP 3800, Ste-Foy, Quebec GIV 4C7.


22/8/85–31/8/85 GREECE, Athens and Rhodes: 10th Congress of European Foresters — organised by the Union of European Foresters and the Panhellenic Unions of Foresters, Forestry Technologists and Forest Rangers. Ref: Dimitrios Kanellopoulos, 1 Pyrgou Street, GR-163 Ano Ilioupolis, Greece.

8/9/85–22/9/85 VANCOUVER ISLAND, VICTORIA, 12th Commonwealth Forestry Conference. ‘Investment in Forestry — Needs and Opportunities.’ Ref: C. E. Brown, 506 W. Burnside Road, Victoria, B.C., Canada V8Z 1M5.

18/9/85 As above: CFA business meeting, Empress Hotel, Victoria.
19/9/85 As above: CFA reception, Oak Bay Beach Hotel, Victoria. Ref: M. T. Rogers, CFA, c/o CFI South Parks Rd., OXFORD, OX1 3RB UK

9/9/85–15/9/85 USSR, Pushkino and Riga: IUFRO Interdivisional Conference on Thinnings. Ref: Dr. L. E. Mikhaylov, Deputy Chairman, State Committee for Forestry, USSR or: Prof. R. Plochmann, Forstwis. Universität München, Amalien st. 52, D-8000 Munich 40, German Federal Republic.

Ref: L'Institut Botanique de Montpellier, Colloque sur l'Arbre, 163 rue Auguste-Broussonet, 3400 Montpellier, France.

Ref: F. J. Staudt, Dept of Forest Techniques and Forest Products, P.O. Box 342, NL 6700 Wageningen, Netherlands.

Ref: PITA, 3 Plough Place, Fetter Lane, London EC4A 1AL.

15/9/85-20/9/85 CANADA, Toronto, Ontario, Muskoka Conference '85. International symposium on 'Acidic Precipitation'.
Ref: Muskoka Conference '85, 112 Clair Ave. West, Suite 303, Toronto, Ontario, Canada M4V 2YS.

16/9/85-20/9/85 WAGENINGEN, Netherlands: IUFRO Regional Workshop (S1.01-00 Ecosystems) Forest Succession in Western and Central Europe.
Ref: J. Fanta, RI for Forestry & Landscape Planning De Dorschkamp, P.O. Box 23, 6700 AA Wageningen.

Ref: L. F. Riley, Chairman IUFRO WP (S3.02.01) Great Lakes Forest Research Centre, CFS 1219 Queen St. East, P.O. Box 490, Sault Ste. Marie, Ontario P6A 5M7.

Ref: R. C. Pierce, USDA Forest Service, Northeastern Forest Experiment Station, Concord-Mast Rd., P.O. Box 640, Durham, New Hampshire 03824.

6/10/85-11/10/85 KNOXVILLE, Tennessee, USA: IUFRO Working Party (S2.01.i5) Whole Plant Physiology Symposium 'Coupling of carbon, water and nutrient interactions in woody plant soil systems'.

7/10/85-11/10/85 KUALA LUMPUR, Malaysia: Asian Water Technology '85.
Ref: International Conferences and Exhibitions Ltd., 6 Porter Street, Baker Street, London W1M 1HZ.

7/10/85-11/10/85 ARGENTINA, Chaco: First meeting on Forestry Information for Latin America and the Caribbean.
Ref: CIBAGRO Direccion de Bibliotecas, UNNE, Av. Las Heras 727, 3500 Resistencia, Chaco, Argentina.

15/11/85-20/11/85 SRI LANKA, Colombo and Kandy: Commonwealth Engineers' Council (CEC) on 'The role of Engineers in Agriculture'.
Ref: CEC, 1-7 Great George Street, London SW1 3AA. (Secretary — J. C. McKenzie)

15/11/85-17/11/85 CANADA — Canada Wood '85, Palais des Congres, Montreal, Quebec.

Ref: E. Heng. ITF PTE Ltd., 1 Maritime Square No. 12-03, World Trade Centre, Singapore 0409.
12/2/86–19/2/86  HANNOVER — CONSTRUCTA '86: International Building Trade Fair.
Ref: Hannover Fairs Info. Centre, 240 Sanderstead Rd., South Croydon, Surrey CR2 0AJ
or: Building Materials Export Gp., 33 Alfred Place, London WC1E 7EN.

Ref: Mr. C. A. Lembke, Chairman Hon. Organising Committee.

Ref: University of Umea, Umea, Sweden.

Ref: David Armstrong, Queensland Timber Board, 5 Dunlop St., Newstead, Brisbane 4006.

7/9/86–25/9/86  YUGOSLAVIA, Ljubljana: 18th IUFRO World Congress.
Ref: Drago Pogorelc, Agrotechnika-Grada, Trzask 132 YU-61000 Ljubljana.

/10/86–/10/86  TANZANIA, Arusha: Inter-disciplinary Seminar on Land Use.
Ref: The Secretary, CASLE, 12 Great George Street, SW1P 3AD, England.

Ref: R. L. Newman, Australian Forest Development Institute, P.O. Box 515, Launceston, Tasmania 7250.
BOTSWANA

The Forestry Association of Botswana was formed in October, 1983. Their first Annual Journal with semi-stiff cover, 73 pages, supported with 13 advertisements, reflects great credit on the volunteers who have nurtured the infant Association. One of the articles which exemplifies this spirit of self-help is based upon the Lion Ivor Scott Forestry Project. The town of Selebi-Phikwée has developed in conjunction with the operations of Bamangwato Concessions Ltd. The local demands for firewood and fodder have been making inroads into the area’s vegetation. Ivor Scott encouraged the local Lions Club to foster a tree planting scheme using land and water available from Bamangwato. The Mmadinare Co-operative joined forces as it was appreciated that the planting scheme would be compatible with their specific requirements for fodder. The first tree was planted in October 1983 by the Minister of Agriculture, the Hon. Mr. Washington Meswele. By the end of 1984, 20 ha had been cleared, half under cultivation with 3 ha scheduled in the early planting programme. The main species is a eucalypt with 5,000 in the ground and another 10,000 on order.

A Botswana Rural Energy study has a funding of £200,000 from the British Government. This is concentrating upon firewood which satisfies 95% of the rural needs. The latest news of the study’s progress can be obtained from Robert Bowls who is working from the Ministry of Mineral Resources and Water Affairs.

Other subjects which the Journal features include, *Leucaena leucocephala*, Social Forestry, Agro-Forestry, fruit, eucalypts and the Tree Nurseries which the Kweney Rural Development Association established at Molepolole in 1973. Part of the success of any tree planting scheme relies upon the co-operation of the local population. This is manifested by the article ‘An attempt at planting some indigenous trees by truncheons in Maun’. The truncheons are heavy unrooted sets. The modest demonstration used *Acacia* branches as a protection for the trees against stock and achieved best results with *Ricinodendron routanenii*, 40 to 80 mm diameter and 1.8–2.5 m long, stripped of branches and inserted 0.3 to 0.4 m into the ground. There was some success with *Pterocarpus angolensis*, *Kirkia acuminata*, *Ficus natalensis*, *Sclerocarya caffra* and *Adansonia digitata* but no growth with *Lannea discolor* or *Markhamia acuminata*. The main problem came from termites which were at work within hours of planting. These were not discouraged with wood ash, they were affected by gamma BHC but it was not until Dieldrin was used that shoot growth could flourish; even with this, it was thought that some adventitious roots were being lost furthest from the surface.

The young Association would welcome any forest literature which members might care to send to David Inger, FAB, P.O. Box 2088, Gaborone, Botswana.

HUNGARY

The following comments arise from the ‘Proceedings of the Hungarian Forest Research Institute’ 1983, Vol. 75. (Erdészeti Kutatások). The Institute has seven research stations around the country and articles are grouped under seven departmental headings.

Genetics, Forest Nursery and Environment: Provenance trials with Douglas fir using 44 seed sources from 51° 30' North in British Columbia, through Washington to 41° 50' in Oregon, planted in 1969 at Zalaerdőd. After 14 years, the mean height was 6.8 m and mean DBH was 10.7 cm. Of the 23 provenances showing above average height, the best Washington results were 9.5 m from Stevens Pass and 8.6 m from North Bend
and from Oregon, Drain at 8.5 m and Estacada at 8.4 m. The latter had the biggest
diameter BH at 13.0 cm followed by Washington sources of Pe Ell, Tenino and Ashford
at 12.1, 12.4 and 11.5 cm respectively. The slower growing British Columbia sources
showed promise for Christmas trees. Elite trees from IUFRO Norway spruce trials
provided cutting material, some of which from one group of clones showed 22% better
height growth at 5 years old than the best from native stands. This group of clones is
considered to be a cultivar *Picea abies* ‘Nyirjes’ and a large scale propagation of cuttings
has been established. There is considerable interest in an elm showing resistance to Dutch
Elm Disease. The ‘Pusta’ elm was developed from Turkestan Elm, *Ulmus pumila* var.
*arborea*. Seeds were received from the Peking Botanic Garden in 1955. It has a coarse
habit, setting seeds at an early age. Annual increment can be as high as 10 to 15 m$^3$/ha.
Adaptable to a wide range of sites, it can be used as a main species where volume
production is required for a market such as chip board (agglomerated board), planted
at 2,000 to 2,600/ha or as an understorey in oak or pine at 200 to 400/ha and at a 50%
stocking 1,300/ha with black locust.

Work study: ‘Investigations and recommendations aiming at the decrease of noise
damage.’ This considers both industrial sites and chain saw operators in the forest.
Workers are reluctant to use the safety equipment provided. Other articles are on the
allocation of responsibility for technical development and some explanations — in
Hungarian — of 93 terms used in afforestation and natural regeneration.

Department of Ecology and Afforestation: ‘Correlation between water quality and
the growth of poplars and willows.’ The English summary emphasises that the results
of deep-boring technology should be studied in conjunction with the soil assessment.
Poplars and willows do well on ‘the carbonate alluvial soils having a humus layer’ but
will not root in ‘strongly salted groundwater’. One article discusses the water retentive
powers of soil colloids and another details the Gödöllő Arboretum.

Department of Silviculture, Yield and Forest Management: Subjects include the
‘Evaluation and utilization of the forest biomass’ ‘poplars’, ‘beech’, ‘sessile oak thinning’
‘Turkey oak’ and ‘hornbeam yield tables’. Although poplar I-214 will yield 27–76% higher
volumes on good ground than Robusta, the dry weight difference is between
12 and 58% higher — the Robusta is heavier for unit volume. The differences between
the two poplars decrease with the lowering of site quality. Thinning of sessile oak can
increase the radial girth of the dominant trees by 10–20%. Turkey oak (*Quercus cerris*)
covers significant areas in Hungary; frost crack is the cause of considerable loss of timber
on conversion. This fault appears to become more common with increasing site fertility;
it is recommended that other species be used on the higher quality sites.

Department of Forest Protection: An article on the control of oak mildew *Microsphaera
quercina* on oak in the nursery and young plantations cites the satisfactory performance
with elemental sulphur, dinakop, benomyl and pirazophos if sprayed fortnightly after
flushing, using up to seven preventative applications in the nursery and 3–5 treatments
in recently established stands. ‘The utilization of waste-wood in the production of
Pleurotus ostreatus’ by Dr. Kiss László suggests that there is an annual equivalent of
about 720,000 m$^3$ of wood refuse from stumps, felling debris and sawdust which might
theoretically produce 14,400 Tonnes of mushrooms. At present it is feasible to use chipped
poplar waste and sawdust in a ratio of 5:1 with boiled oats, suitably inoculated with
the fungal preparations from the Research Institute. The returns, within two months,
can show 300 to 600% profit. Dr. Wanda discusses the microflora of beech mast and
seedlings.

The Department of Technical Development assess the Kockums GP-822 Processor.
Seven modifications were evaluated, three of which show promise. The average production
was 3.6 m$^3$/hr. Even in the most appropriate conifer plantations and poplar stands, the
high capital cost made it less desirable than other ‘crane-processors’ which might be mounted on any suitable vehicle.

The Department of Forest Economics: ‘Local timber values are influenced by the major market prices around the world.’ ‘Assessment of young plantations based upon compound interest and more mature forests upon discounted anticipated revenues.’ ‘Forest Recreation.’ By the year 2000 it is thought that Hungarians will spend 44–74 M leisure days in the forest with a further 4–8 M days being enjoyed by foreign tourists. The English summary says that the planned intensive development of recreational forests will meet the increasing demands. The figure of 319 ha by 2010 appears conservative but the Russian summary also mentions ‘319 ra’ by ‘Ha 2010’.

A report by the Department of Agricultural Sciences traces the development of forestry following the considerable demands upon foreign currency for timber following the war of 1914–18. Since 1950, 0.5 M ha of new forests have been established. During this period, the volume of wood used doubled, but the percentage of home grown rose from 56% to 67%. It is planned to increase this percentage to 75% by 2000 and at the same time to develop the other attributes which the trees and forests can afford.

**IVORY COAST**

The Commonwealth Development Corporation has already helped with the finances of the ‘Ivory Coast Hardwood Forestry Project’ which has established 21,700 ha of timber. A further 20,000 ha will be cleared and planted over the next five years. The total cost of project is expected to be £42.7 M with US $31.3 M coming from the World Bank and £8 M from CDC, some of which appears to be the rescheduling of the £5.8 M loan agreed in 1979. The new forests are expected to produce 6.6 M m$^3$ of timber over the next 35 years.

**NEW ZEALAND**

‘Forest Products News’, the house journal of N.Z. Forest Products Ltd., records the Company’s holding of over 215,000 ha of which 165,000 ha is forest. In addition to the Company’s main area centred on Kinleith in the middle of North Island and outlying forests, it has a joint project with Shell Forestry New Zealand Ltd. in Northland and at Ngatihine, an operation with Alex Harvey Industries Ltd. and Carter Holt Holdings Ltd.

The main species is *Pinus radiata*, a native of California. Seedlings reach 30–50 cm in nine months having had both tap roots and lateral roots pruned. Planting on prepared sites at a stocking of 1,100 stems/ha, it is possible to select potential final crop trees at 350/ha and prune these selected stems between the 5th and 9th year. This increases the chance of producing desirable veneer logs. The trees are harvested around 30 years of age, when they may be 40 m tall with 2 to 3 m$^3$ of timber. The material which is not suitable for veneer or for milling is chipped for particle board, hardboard and paper. ‘Forest Products News’ is printed on their own paper. The area of plantations in New Zealand now exceeds 1 M ha, producing 10 M m$^3$ now, increasing to 20 M m$^3$ by 1990 and 30 M m$^3$ by 2000. The Company’s area of new planting is about 700 ha annually, with a further 2,500 ha of replanting. This has already required the building of 4,000 km of road with a current programme for the year of 120 km, the quarrying alone for this entails 200,000 m$^3$ of rock.
PAKISTAN

The chip board industry of Pakistan is featured in an article by Wulf Killmann in the April 1984 issue of the *Pakistan Journal of Forestry* Vol. 34, No. 2. The bulk of the timber felled is used as fuel wood, approximately 16.6 M m³ annually. Timber and timber products use 2.033 M m³ of which about half is imported. Chip board production dropped from 14,108 tons in 1972 to 10,000 t in '77/'78 but rose to 26,009 t by 1980. Bagasse has represented an increasing proportion of the raw material, now representing 70%. Six new mills opened between 1980 and 1983 to bring the number up to 12 with two more sanctioned. The capacity for production is about three times the present consumption.

TANZANIA

The Principal Secretary in the Ministry of Natural Resources and Tourism, Ndugu R. M. Shirima, was reported in the Daily News, quoting the volume of timber felled in 1983 for fuel as 40 M m³. The suggested sustainable annual figure was 19.6 M m³, the balance being removed was capital which should have been left to provide increment for subsequent years. The planting programme between 1975 and 1980 had been an annual figure of about 10,000 ha with 12,000 ha in 1981, 14,459 ha in '82/'83 and a further 38,167 ha anticipated over the '84/'86 period. However, the desirable annual planting programme should be 200,000 ha. Individual families are encouraged to plant 80 trees a year and in addition, to protect the remaining trees from the ravages of bush fires.

TRINIDAD AND TOBAGO

Trinidad has an area of approximately 4,825 km² lying 18 km east of the coast of Venezuela. Tobago lies 35 km north east of Trinidad and has an area of approximately 300 km². Dry land and swamp forest covers 54% of the islands — 277,339 ha — of which 222,949 belong to the State and 54,390 ha are owned privately. The State forest includes 15,400 ha of swamp, 36,959 ha of protective forest and 94,300 ha of production forest. The species used in plantations include Teak (*Tectona grandis*), 8,121 ha in 1978, and pine (*Pinus caribaea*), 3,814 ha in 1978. The 1979 Annual Report shows additional planting of 389 ha of teak, 329 ha of pine and 247 ha of mixed hardwoods — including *Cordia alliodora*. There are 30 species which feature in the annual felling returns, producing some 3 M m³. The volume of *Mora excelsa* felled between 1973 and 1978 had an annual range of between 0.4 M m³ and 1.3 M m³. *Carapa guianensis* figures for the same period varied between 0.19 M m³ and 0.37 M m³. The match industry, which was based upon *Didymopanax morototoni*, is needing to import timber from Canada. Canada is helping with the funding of ‘Institutional Consultants International Ltd.’ in the surveying of the Islands’ timber resources. The reports for the years 1980–83 should shortly be available from Dr. Bal S. Ramdial, Forestry Division, Private Bag 30, Port of Spain, Trinidad.

UNITED KINGDOM

The Forestry Commission figures released at the close of the '83/'84 season show the area of High Forest as being 2.018 M ha, the area of the country being 24.1 M ha. The Forestry Commission's area is 0.902 M ha of which 0.851 M ha is conifer. The area of Private Woodlands is 1.116 M ha of which 0.572 M ha is conifer, 0.506 M ha is
broadleaved with a further 38,000 ha of broadleaved coppice. The annual Forestry Commission planting programme between 1977 and 1984 has ranged from 15,000 ha to 21,500 ha of which restocking of felled areas has risen from 3,100 ha to 6,700 ha. Over the same period, the Private planting ranged from 9,600 ha to 20,100 ha with restocking being 2,100 ha to 3,500 ha. The apparent consumption of wood by the UK, including pulp, panel products and paper ranged between 36.3 M m$^3$ and 43.9 M m$^3$ with the home production supplying 3.8 M m$^3$ to 4.3 M m$^3$. The total employment in forestry and the wood processing industries during 1983 was 26,195.

The £12 M orientated standboard mill at Dalcross is expected to start normal production by July, 1985. There are 35 similar plants operating around the world but this plant has been designed to accept material down to a 60 mm diameter which should prove popular with suppliers. The £135 M Shotton thermo-mechanical pulp and newsprint mill is expected to produce 200,000 T of newsprint annually. Commissioning has reached the press trial stage and regular deliveries are anticipated by July, 1985.

The Director General, Mr. George Holmes, has announced the re-organisation of the Forestry Commission with the number of conservancies reduced from 11 to 7 with 70 Forest District. The three full-time Commissioners and their respective Divisional Heads will be as follows:

Operations: Mr. Gwyn Francis with the responsibility for:
- Harvesting and Marketing: Roger Bradley
- Silviculture: John Aldous
- Engineering: Roger Hay
- Estate Management: John Gwyn

Private Forestry and Development: Mr. John Kennedy has the following Divisional Heads:
- Private Forestry and Services: Alastair Rowan
- Research: Arnold Grayson
- Planning and Surveys: David Grundy
- Public Information: Peter Drumm

Administration and Finance: Mr. Derek Rutherford's Divisional Heads will be:
- Finance: Colin Turquand
- Personnel: Charles Simmonds
- Secretariat: Peter Clarke
- Data Processing: Edward Arthurs

ZIMBABWE

The *Timber Trades Journal*, 2 March, 1985 mentions the construction of a Wood Technology Centre at the University of Zimbabwe with the help of the Tree Technology Centre of Norway. Norway will provide $2.5 M for the project and a further $150,000 in 1985/86 for consultancy services at the Centre.
FORESTERS AND POLITICS

By Jack C. WESTOBY*

SUMMARY

The paper discusses the responsibilities of political authorities and of foresters for national forest policies, as set out by the Final Declaration of the Seventh World Forestry Congress and elaborated by the Eighth Congress. It notes that few countries have responded to the calls to define or renew their forest policies, and examines some of the reasons why.

The experiences of the last decade or so, point to a number of ways in which the conceptions of national forest policies put forward by previous Congresses need to be amplified. The need for such policies becomes ever more urgent. Foresters have a particular responsibility for helping society to discover and formulate the variety of its needs from the forests. Traditionally foresters have been custodians of the interests of the voiceless — the unborn generations; their skills should also guard the forest needs of the weaker and less vocal sections of society. In the past, foresters have tended to look — with only modest success — to politicians to define long-term community interests. Today, anxiety about the future of the forest resource is everywhere growing, and conditions are increasingly propitious for raising forest consciousness. Foresters, whether in private or public employ, should exercise their rights as citizens and speak out with a free and independent voice. They must turn to the people, providing them with the armoury of resource knowledge and understanding that can ensure policies which match society's needs.

Forests, woodlands and trees, both extant and yet to be planted, have a crucial role to play in the integral development of society. An important first step towards that objective is the full integration of foresters into society.

Introduction

Where do the forester's responsibilities lie? To whom or to what does the forester owe allegiance? What are the responsibilities of governments concerning a nation’s forests?

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This paper recalls the answers given to these questions by the Seventh and Eighth World Forestry Congresses; considers how far those answers are still adequate; explores some matters left unexamined in those Congress’ formulations; and goes on to consider some of the implications.

The responsibilities of governments

The Final Declaration of the Seventh World Forestry Congress [Buenos Aires, 1972] centred its attention on the responsibilities of governments. It said [paragraph 7]:

Recognizing that in many countries, declared forest policies are not in accord with new knowledge, new preoccupations and new aspirations, the Congress considers it is now urgent to redefine forest policies in view of these new circumstances. The Congress firmly believes that, whatever the political objectives, whatever the form of economic organisation, whatever the present pattern of land tenure, governments are responsible for planning the continuous flow of the productive, protective and social goods and services from the forest, ensuring that the physical output and environmental benefits of the forests are available for the general welfare of their peoples now and for all time. Since we live in one world, and since the world’s forests are unevenly distributed, national policies and plans should take account of the international context.

This rests firmly with governments, i.e. with the central political authorities, the responsibility and the initiative in having a forest policy and ensuring that it is implemented. Could this formulation be improved upon?

Yes, it certainly could. National and international experience during the last thirteen years, including the Eighth World Forestry Congress at Jakarta in 1978, suggests it could be amplified, be made better and more precise, in a number of ways. Thus already by 1978 it was understood that governments’ responsibilities for the flow of goods and services from the forest could not be discharged regardless of the socio-economic environment. This is why the Jakarta Declaration, discussing the contribution of forestry to the rural poor of the developing world, extended the argument [paragraph 7]:

A commitment to rural development on the part of foresters will be of no avail unless there is a firm commitment on the part of governments. Such commitment must include action to reduce inequalities in the countryside, notably in the distribution of land and in access to social and support services. It means encouraging self-reliance, mutual aid and cooperation. It means recognizing people as the motive force of development, not simply as the passive object of development.

What this says is that a national forest policy which includes rural betterment amongst its stated objectives is valueless in the absence of associated political commitments. The Buenos Aires declaration seemed to assume that the responsibility of the political authorities (‘for planning the continuous flow . . . for the general welfare of their peoples now and for all time’) could be discharged whatever the pattern of land tenure, the forms of economic organisation, etc. Not so, said the Jakarta declaration, that implicit assumption is invalid. Commitment to a national forest policy with the objectives of the Buenos Aires Declaration requires certain parallel political commitments.

Thus the Seventh World Forestry Congress Declaration was a political statement, though the political implications were not spelt out at the time — and, indeed, may not have been fully recognized by some of the Congress participants. The Eighth World
Forestry Congress Declaration was a good deal more sophisticated. Forests for people? Yes. But if national forest policies are truly to serve the interests of people, then overall socio-economic policies must be working in the same direction. There must be commitment to a greater measure of social justice, to more equal access to land and other resources, to the participation of people themselves in the developing process. And even if not all the participants at Jakarta understood this and digested it at the time, the years which have passed since 1978 have underlined the point.

Jakarta, then, imported some corrections to Buenos Aires; it started the process of giving greater precision to the Seventh World Forestry Congress Final Declaration. Let us assume that this Ninth Congress, having taken as its theme ‘Forestry Resources in the Integral Development of Society’, will wish to continue that process. What other amplifications, amendments, precisions are needed?

The list of suggestions which follows makes no claim to be exhaustive. It is based on a personal appraisal of the evolution of forestry concerns in the world over the last thirteen years, and it is intended simply to serve as a starting point for discussion.

1. The scope of the declared national forest policy should not be unnecessarily restrictive. Forest policy is concerned with all places where, and every way in which, forests, woodlands and trees can contribute to human welfare.

2. Similarly, policy relates not only to existing forests, but to forests yet to be created, to woodlands and trees yet to be planted.

3. The policy will serve as a directive and guide, not only to the forest services, but to all agencies and departments, national, regional or local, having a measure of responsibility for implementing the policy.

4. Where appropriate, the policy should accord special emphasis to (and therefore make special mention of) the role of forests, woodlands and trees in:
   a. providing a wide variety of support services to agriculture;
   b. contributing to appropriate agroforestry and sylvopastoral systems;
   c. specifically promoting the welfare of the rural poor, both small peasant proprietors and rural landless;
   d. contributing to the fuel and energy needs of both urban and rural people;
   e. improving the quality of the urban environment; and
   f. rehabilitating marginal lands.

5. The forest policy should be arrived at through a widespread and democratic process of consultation and should thus be such as to command a rather broad consensus, and possess a consequent moral authority. The consensus will not, of course, be complete. There are many conflicting interests in the forest, and not all of them are reconcilable. Some are much less vocal or politically powerful than others. In the past, foresters have fought, often alone, for the least vocal of those interests — that of future generations. It is fitting that today, especially in the light of the Eighth World Forestry Congress, they should assume a special responsibility for safeguarding the interests of the rural dispossessed and the urban poor.

6. It is important that all those organisations, classes and groups which will have responsibilities in implementing the forest policy should be actively associated with its development. In many developing countries the categories whose involvement is likely to be decisive include peasant organisations, rural trade unions, cooperative and mutual aid groups, village councils and organisations of rural women.

7. While short-term forestry goals and targets may be subject to change, the broad objectives and directions of the forest policy should be changed only through a further democratic process of consultation.

8. The national forest policy should be an integral part of, indeed the principal pillar of, a national conservation strategy. However, it need not wait until the process
of preparing and winning a sufficient consensus for a national conservation strategy is completed, since the latter will almost certainly invoke issues which are more complex and contentious. It will often be more appropriate to make a national forest policy the first instalment of a national conservation strategy.

9. A most important function of the national forest policy is to serve as a tool of education and animation: for deepening forest consciousness and for mobilising popular support for the forest policy. This objective should determine the language in which the forest policy is written. A preamble setting out in clear, easily comprehensible terms the principal services rendered by forests, woodlands and trees may help it to serve this purpose.

This list is not necessarily complete. There may well be other amplifications and amendments which would clarify and make more precise the purposes of forest policy. The reasons for most of the changes suggested here will be apparent to all those who have closely followed the evolution of forestry preoccupations over the last decade. The reasons for others emerge from the discussion below.

It will be observed that, like the Jakarta extension of the Buenos Aires declaration, the amplifications suggested above are rooted in commitments to social justice, to freedom of discussion, and to the democratic process — all of which are preconditions of placing trees fully in the service of people.

However, it is a matter of common observation that not all who presently exercise political power share these commitments, and that the willingness of governments to adhere to them in theory greatly exceeds the extent to which they are respected in practice. It is this which makes it exceedingly difficult, if not impossible, for foresters who wish to dedicate their knowledge to the integral development of society to be politically neutral. Moreover the obstacles raised by governments, and by social-political conditions more generally, to putting forests properly in the service of the community, are both numerous and various. If, therefore, this Ninth Congress is to go beyond the pious generalities appropriate to an ideal political world, it must consider the responsibilities of conscientious foresters, and the problems which may face them, in varying — and not infrequently difficult — political circumstances.

The responsibilities of foresters

The Seventh World Forestry Congress declaration also had something to say about the responsibilities of foresters [paragraphs 13 and 14]:

[13] . . . Foresters have been pioneers in the struggle to conserve and rationally use renewable resources. As men and women experienced in the multipurpose management of the forest resource, they cannot but view with satisfaction the growing concern about environmental quality and the need for proper management of the world's renewable resources. Foresters recognize that forestry is concerned not with trees, but with how trees can serve people.

[14] This Congress declares that the forester, being a citizen as well as a professional, has the clear duty and responsibility to ensure that his informed judgment is heard and understood at all levels of society. His allegiance is not to the resource, but to the rational management of that resource in the long-term interest of the community. To this end, forestry education needs to be broadened, with greater emphasis than heretofore on those disciplines that contribute to the understanding and exercise of the forester's responsibility.
In paragraph 13, foresters, never averse to blowing their own trumpet, contented themselves with a modest blast (‘foresters have been pioneers’). A more defiant reminder might well have been justified, since foresters were already in 1972 finding themselves assailed by conservationists with seemingly no sense of history, evidently unaware that down the ages foresters have often been heroes, and sometimes martyrs, in the cause of conservation.

Paragraph 14 clearly sets out the principle of the social responsibility of foresters. Moreover, the problems arising from the fact that the overwhelming majority of foresters are employed in public service is tacitly recognized (though not, as we shall see below, fully ventilated).

There was, and still is, a widespread tradition that public servants should be seen and not heard, that they should abstain from public debate, that their views are properly expressed only in interdepartmental memoranda and aide-memoires to Ministers. It seems to have been the opinion of the Seventh Congress (though it neglected to say so in so many words) that this tradition needs to be shattered, that the de facto disenfranchisement — the political castration — of public service foresters should be ended. Thus foresters should resume their rights as citizens. They have the duty to ensure that their informed judgment is heard in all public debates on resource issues.

Now had all this been spelled out in 1972, it is possible that foresters would have been better equipped to deal with some of the problems they have been confronted with since. If forestry is to be people-oriented rather than tree-oriented (and in this regard the entire proceedings of the Eighth World Forestry Congress served to endorse and further develop paragraph 13 of the Seventh Congress Final Declaration); and if the forester owes his or her first allegiance not to the resource as such, not to his employer, not to the current political authority, but to the long-term interests of the community, then it follows that foresters must give more serious consideration than they hitherto have to their relations to politics and politicians. In some respects, as we saw above, the Eighth World Forestry Congress came closer than the Seventh to nailing down the relation between foresters and politics, but it nevertheless left much unsaid. The occasion of this Ninth Congress invites some clarification.

The forester in private employment

Conflicts between long-term community interest and short-term private interest have always arisen in forestry, and still arise frequently. Indeed, forestry science may be said to have been born out of this conflict. Forestry’s pioneers, only a few generations ago, had no doubts where their duty lay. Nor today should their successors be in any doubt. They must not allow themselves to be bemused by catch phrases such as ‘you must not bite the hand that feeds you’. If conflicts of interest arise, their first duty is not to their employer, but to the public interest. And if it should happen that the hand that feeds the forester is simultaneously screwing the public, then it becomes the forester’s duty to bite that hand, and to bite it hard. Some professional forestry societies have already recognised the primacy of public interest, and have incorporated this principle in their professional code of ethics (for example, in New Zealand). Not only should other societies follow suit, all should make it clear that they intend to protect any of their members who may be victimised as a consequence of putting the public interest first.

This issue came into prominence a few years ago in the State of California, which has a system of licensing foresters. State law requires that all timber harvesting on private lands must be done under a plan prepared by a state licensed forester. The State may
reject that plan if it is not satisfied that, in preparing it, the registered professional forester has not only considered the possible impact of harvesting on production and productivity, on soil, water and range values, recreation and aesthetics, but has selected and incorporated in the plan those feasible silvicultural systems, operating methods and procedures which will significantly lessen adverse effects on the environment.

Some of the older generation of Californian foresters argued that this was an impossible task. Either we loyally take care of the interests of our employer, they said, or we put the public interest first. We cannot serve two masters.

Eventually, the Chairman of the State of California’s Board of Forestry, in a letter to all the State’s registered professional foresters, pointed out that all parties — owners, operators, employers, clients, and foresters, whether in private or public employment — were obliged to comply with applicable State laws, and consequently to respect the public values expressed in them.

In one sense, the Californian foresters’ task was easy, since the Californian legislature had spelled out public values — in such laws as the Forest Practice Act, the Environmental Quality Act, the Coastal Act, and the Wild and Scenic River Act. And the letter from the State Board of Forestry’s Chairman was, thus, both wise and shrewd. Wise, since it rested on, and directed attention to, the law. But also shrewd, since it sidestepped the 64 dollar questions: What is the public interest? And who shall define it?

Defining the public interest

It is no easy matter to define the long-term community interest. Certainly it cannot automatically be equated with the aggregate of objectives expressed in the bundle of relevant Californian laws. Each of those laws dealt with a particular problem; most were originally pressed on the legislature by particular lobbies. Added together, they do not necessarily represent the views of all users of forest goods, services and values, nor even a cogent balance of those views. Only the kind of nationwide discussion, with all the relevant facts available, that we have envisaged for arriving at a national forest policy can lead to an acceptable definition of the long-term community interest. Yet it is for the community, not for foresters, to decide. The forester’s task is to help different sectors of the community to discover what they want from the forest. And even when the long-term community interest has found documentary expression, that document can have no permanent validity. It will require periodic review, in the light of changing public values and changing technology.

However, even though the public interest may be difficult to define positively, and even where it has not yet found expression in either a declared national forest policy or some kind of legislation, it is normally a much simpler matter to identify certain actions as being contrary to the public interest. The forester is never absolved of his professional obligation to put the public interest first. He is entitled to look to his professional society for guidance, and societies would do well to build into their codes of ethics some guide lines, a list of actions which should prima facie be regarded as contrary to the public interest. And, even if his professional society fails to provide him with such a yardstick, the individual forester is by no means helpless. He has his own in-built sense of right and wrong. And that, after all, is the sole equipment with which many of the pioneer foresters faced the world. For example, it requires neither a statute nor a formal code to recognise that aerial spraying which contaminates public water supplies is wrong; that careless roading which fosters erosion, carrying silt downstream, is wrong; or that forest habitat destruction which brings the genocide of forest-dwelling communities is wrong.
The fact that there may be some areas which are grey must not lead us to suppose that black and white do not exist.

The forester in public service

But what about the other, more difficult, case: that of the forester in public employ? Is not a forester employed in the public service ipso facto acting in the long-term community interest, in the public interest? Such a presumption can only spring from ignorance, or naivete, or both. The political map of the world swarms with countries where any identity between the actions of its government and the long-term interests of its people is as fortuitous as it is rare. Nor do all these countries lie in the Third World.

Even in the older pluralistic democracies such a presumption may not be warranted. For it has to be acknowledged that the first allegiance of those holding political power is, as a rule, to themselves, to retaining that power. In recent years we have seen how those for the time being in the political saddle are prepared to suppress information, and to promulgate false information, for political ends.

Now if governments and Ministers are prepared to lie to parliaments and people, not for reasons of national security, but for party political advantage, what is the duty of the civil servant? It is his duty to puncture such deceptions, to ‘blow the whistle’; it is the mendacity of politicians, not declining standards among public servants, that make of whistle-blowers front-line guardians of our civil liberties.

What has just been said applies to all civil servants. Foresters differ from some other categories of civil servants in that, collectively, they possess an uncommon stock (though not a monopoly) of resource knowledge and experience, and in countries where all or most foresters are employed in the public domain, access to that stock of knowledge is not easy. Yet without access to it laymen and women cannot hope to propel their politicians into intelligent decisions on the nation’s forest resource. If foresters are muzzled, are not free to discuss and criticise government policies, then there is no hope of building up the alert and informed public opinion which should be the foundation of — and in the long term is the only guarantee of — a sensible resources policy.

All this, perhaps, sounds too commonplace to be worth repeating. Yet in recent years there have been several instances either where pressure has been put on foresters to deter them from speaking their minds or where foresters have been reluctant to express their views lest their careers be jeopardised. Foresters’ professional societies, and especially those of their members who are employed in the relative freedom and security of universities, have a particular responsibility to guard the independence and integrity of such colleagues.

Summing up: the responsibilities of foresters in the public service are a matter of concern at two distinct levels. First, all foresters are citizens, and citizens whose specialist knowledge carries special responsibilities. Being in public service should not disenfranchise them. They have both the right and the duty to engage in public debate, on forestry issues as on others. In countries where most foresters are in public service, that duty is all the more compelling since laymen and women must rely heavily on them for the expert knowledge which enables the citizen to distinguish between alternative resource policies.

The second level of responsibility particularly concerns those top foresters who are advisors to, and confidants of, Ministers and politicians. The people who have put Ministers into power (and who are the ultimate employers — the paymasters if not the masters — of both Ministers and civil servants) have the right to the truth. Top-level foresters must not connive in keeping it from them.
The role of professional forestry societies

The forestry profession is not an archetypal profession, formed for the mutual protection of the learned self-employed. It was born under different circumstances, and from its inception it has been (pace George Bernard Shaw) more of a conspiracy for the layman than against him. We have seen how forestry professional societies, providing they are vigorous and alert, can help foresters to promote the public interest against pressures from private employers and politicians in the pluralist democratic societies. Have they any role in other societies: in one-party states, in military dictatorships, or in regimes which are not only authoritarian but corrupt?

The public service forester who finds himself locked into an essentially corrupt regime has dire need of our understanding and support. Most who have been privileged to work in international forestry will have encountered Ministers and forest departmental heads whose life styles are quite incompatible with their official salaries, and whose relations with concessionnaires are far more intimate than simple business connections would require. At the other end of the scale, we have observed the futility of trying to discipline field staff who are more or less obliged to supplement abysmally low wages by laxity in tree marking, log grading, etc.

Corrupt regimes are not, fortunately, the inevitable consequence of underdevelopment, even though the development strategies sometimes wished on underdeveloped countries might have been designed to favour the dishonest. Even under the most notoriously corrupt regimes, the overwhelming majority of ordinary people, and of foresters, are honest. Have we no message to convey to the thousands of conscientious foresters whose daily work obliges them to become accessories to crimes perpetrated on the forest resource at the expense of the people? Alas, it must be acknowledged that there are few positive and immediate remedies open to us. We may explain that dishonesty is not the norm; that corrupt regimes are, more often than not, short-lived; and that foresters who decide to resist them can rely upon international professional sympathy and even, where practicable, on a measure of aid. But we cannot generally do more.

However, expatriate foresters who find themselves serving in such regimes have a special responsibility. Circumstances can never justify their placing their professional integrity in cold storage. They can always terminate their contract, unambiguously explaining the reasons both to the host government and to their sponsoring agency. This is a luxury which few of their counterparts in the country, however honest, can afford. The services of the expatriate forester may have been assigned to the host government, but the dictum which enjoins those living in Rome to do as the Romans do is false counsel. Our professional responsibilities stand higher than the avoidance of frictions, and the expatriate forester should permit no misunderstanding: neither he nor his sponsoring agency can in any way connive at corruption or the despoiling of a public resource.

Yet to do what is right in such circumstances can require of the individual a more than everyday exerciser of moral backbone, and it is here that the solidarity of foresters is put to the test. Those of our colleagues who find themselves in such situations must be able to count on the organised support of foresters’ professional associations, both nationally and internationally, and the more serious cases which come to light must be taken up by our professional bodies, which should consider what kind of public exposure could best serve the efforts of the foresters involved to promote honest practice.

What about the responsibilities of foresters in regimes where the political order insists upon an obsequious identification with the ruling party’s prevailing line? In almost all of these countries the state is the only employer — and the individual is at the mercy of the state when it decides that dissent shall be regarded as anti-state activity. Yet living controversy, with full freedom of discussion, is the only way in which science can advance;
and, as we have argued, it is also the precondition of forestry policies which will fully serve people. The political pendulum, swung from on top, can produce situations which border on the grotesque, as in China, where it seems inevitable that yesterday’s heroes become today’s villains and tomorrow’s rehabilitees. Thus, contributions to China’s professional and popular press on forestry are currently required to start from a listing of the crimes of the Gang of Four, and consequently a picture of the forestry situation assembled from such sources bears no relation whatsoever to the findings of highly competent professional observers who have visited and travelled widely in China. It is, therefore, consoling to know that, whatever the crimes of the formerly infallible, not all of the many millions of man-days put into afforestation by China’s patient and long-suffering peasants have been wasted.

Perhaps we can do little more than have faith that eventually, in all these authoritarian states, whether of the right or the left, a hundred flowers will indeed be allowed to bloom, and a hundred schools of thought contend. Meanwhile we should insist that our own professional forestry societies maintain a vigorous and independent intellectual life, and encourage them to foster ties, and to extend the most vigorous support, to all colleagues and sister societies in other countries who must struggle if they are to maintain their autonomy.

Where are those national forest policies?

How have countries so far responded to the call of the Seventh World Forestry Congress, reiterated by the Eighth Congress in paragraph 26 of the Jakarta Declaration: that all countries arm themselves with a declared forest policy, and that those policies already extant be updated? What has been the response?

It has been almost negligible. The sad facts, much though we may deplore them, are that even now relatively few countries have a declared forest policy. Of those which have, not all have updated their policies since 1972. In the pluralistic societies, few of the major political parties have anything approximating to a forestry platform. At general elections, forestry issues figure very seldom. Where they surface at all, they tend to be local or partial, rarely engaging national policy. Why is this? Why do nearly all politicians, and most lay people, take us much less seriously than we take ourselves?

There are, in almost every country, still too few people who truly care about a national forest policy. And that is because too few people understand forests’ contribution, actual and potential, to material welfare and to the quality of life. For this state of affairs foresters are themselves partly to blame. They have ascribed too much importance to politicians, and too little to people. Forest policies have frequently been hatched between top echelon foresters and the reigning politicians. The latter have normally consulted the more powerful vested interests (forest industry associations, large forest owners) before deciding policy. Often it has been considered more flexible and less tying not to give the forest policy a precise, declared, ‘manifesto’ form. Then, if adjustments are needed, politicians and top foresters can make the necessary fixes in the corridors of power. But because foresters have chosen to lean too much on politicians and too little on people they have found themselves without visible means of support when politicians have opted, for example, for short-term private interests against long-term public ones, or in other ways have sacrificed principle to expediency.

This Ninth World Forestry Congress, having taken as its theme ‘Forest Resources in the Integral Development of Society’, will almost certainly wish to have its deliberations summed up in a concluding Mexico Declaration. Some of the elements which should feature in this Mexico Declaration are suggested and discussed earlier in this paper. But
if this 1985 call from the foresters of the world is to have greater impact than preceding calls, then the Mexico Declaration must throw into relief the need for foresters to look to people, rather than to politicians, to ensure that forest resources play their rightful role in the integral development of society.

Foresters must turn to the people

‘People’, ‘popular’, ‘populist’: lovely-sounding words, conspicuous in the vocabulary of the demagogue. But they do have a real meaning, and they can be used without being demagogic. It is not demagogic to believe that there can be a national forest policy which is publicly stated, in language which is not obscure, which is vigorously debated at all levels and over a sufficient period, and which through that very means becomes a genuinely popular national forest policy.

Although in most countries too few people as yet either understand the role of forests or care about forest policy, never has the time been so propitious as now for building a consciousness about forests and arousing concern about forest policy. Here are some of the reasons why.

1. The last few years have seen a tremendous upsurge of interest in the shrinking of the world’s tropical forests, with the concomitant disappearance of thousands of species of flora and fauna whose potential utility to the human race has never been appraised. Innumerable books, films, television programmes and magazine articles have brought this problem to public attention, especially in the industrialised countries. The International Union for the Conservation of Nature and World Wildlife Fund International can take much of the credit for this unprecedented campaign. True, it has had limitations: it rarely exposed the socio-economic causes (and hence political roots) of tropical deforestation; and it seldom related tropical deforestation to the (often quite serious) forestry problems arising within the countries which the media addressed. Nevertheless, the upshot of the campaign is that tens of millions have had their ears tuned to receive lucid and convincing messages about the importance of forests.

2. The heart-rending images of famine-swept Africa which have penetrated the living-rooms of the affluent countries have led millions to understand for the first time that there is an association between treelessness and starvation.

3. The World Conservation Strategy, launched simultaneously by multilateral inter-governmental and non-governmental organisations, while slow to win truly popular backing, is nonetheless directing the attention of important sectors of opinion to the need for more far-seeing resource strategies, particularly for renewable resources.

4. There has been, especially in the industrialised West, a mounting concern over environmental threats. This concern expresses itself in different ways, but it is too often focussed on local dangers, and parochial, even self-centred, in outlook. Foresters have the knowledge and the ability to frame these concerns within a wider context, and thus to give them ethical content.

5. The present generation of foresters has several advantages over its predecessors. With the realisation that the forester does not stand alone as a resource custodian and repository of resource knowledge has come a new humility, a new readiness to consider the views of others as to the weighting to be given to the various calls on the forest, and in consequence a greater likelihood of being listened to.

Because the prospects for raising forest consciousness worldwide have never been better, this Congress, in preparing its Final Declaration, may wish to call upon delegates, on
returning to their own country, to plan for a nationwide campaign to win the widest possible support for a declared national forest policy; or, in those cases where such a policy already exists, a campaign to update it. The Annex to this paper makes some suggestions for organising such campaigns.

In taking the initiative to mount parallel campaigns in many countries, aimed at winning commitment to declared national forest policies, foresters will be simultaneously

a. reaffirming their commitment to ‘Forestry for People’;

b. recognising that this commits them to certain minimum social and political objectives, e.g. greater equity in access to natural resources, freedom of discussion, and social justice;

c. acknowledging their responsibility for helping all classes of citizens to discover their own needs from a forest policy;

d. insisting on their right as citizens, whether in private or public employment, to express themselves freely on all aspects of forest policy; and

e. recognising that a national forest policy can be effective only if it rests on, and has won broad acceptance from, an informed citizenry.

Or, to put it another way, the first step in ensuring the optimum role for forest resources in the integral development of society is to ensure that foresters themselves are fully integrated into society.

ANNEX:
CAMPAIGNING FOR A NATIONAL FOREST POLICY

Such a campaign might proceed by the following steps:

1. Preparation, either by Congress ex-delegates or by the foresters’ professional society, of a preliminary draft for discussion. This draft should be conceived as a major contribution to an eventual national conservation strategy. In those (very few) cases where a national conservation strategy has already been adopted, the draft national forest policy will elaborate one section of the national conservation strategy. The draft will be provisional and open to amendment. On points which are likely to be contentious, it may include alternative drafts for discussion.

2. This draft should be circulated to all conservationist groups in the country, and a meeting or, if necessary, a series of meetings organised between representatives of foresters and conservationist groups with the object of arriving at a jointly agreed draft. At this stage it may be worth considering the establishment of a standing committee of foresters and conservationists to further consultations on the agreed draft.

3. From this point the campaign may proceed along three parallel lines of activity:

a. Already the draft can be popularised, through the schools, the media, political parties, etc., and comment invited;

b. Consultations (but not yet negotiations) should proceed with the ‘strong’ vested interests, and their views be ascertained. These may include forest industries, timber trades, national farmers’ unions, trades unions, private forest owners, etc.

c. It may be desirable to preface consultations with the ‘weak’ vested interests by the establishment of study groups designed to help those interests discover what kinds of forest policy can best serve them. ‘Weak’ interests may include urban poor, rural landless, small forest owners, squatters, women’s organisations, ethnic minorities (especially forest-dwelling tribes), etc.
The purpose of these parallel lines of activity is two-fold: to attempt to even the terms on which those with an interest in the forest policy can bring their influence to bear; and to start building up support for a policy which represents a fair and balanced reflection of those interests.

4. At this point it should be possible to draw up a final draft ready for promotion through the legislature on a politically non-partisan basis. Here the true battle starts, in the course of which the most powerful lobbies will try to shift the balance of the draft document in their favour. This is the time when the best efforts of the committee sponsoring the bill (which by now will have been expanded to include all interests subscribing to the bill) will be needed to defend its essential features. The committee will be particularly concerned to defend the interests of the weaker voiced and the unvoiced, i.e. future generations.

5. Once the bill is law, then it — or a paraphrase of it shorn of legal technicalities — becomes a document for education, agitation and further discussion.
**PINUS PATULA SUBSPECIES TECUNUMANII: THE APPLICATION OF NUMERICAL TECHNIQUES TO SOME PROBLEMS OF ITS TAXONOMY**

By P. S. McCARTER* and J. S. BIRKS*

**SUMMARY**

The problems of distinguishing *Pinus patula* Schiede and Deppe ssp. *tecunumanii* (Eguiluz and Perry) Styles from *P. oocarpa* Schiede in mixed natural stands in Central America prompted this taxonomic investigation which examines relationships within and between provenances of the two taxa. Orthodox taxonomic descriptions are shown to be unsatisfactory in aiding discrimination between them.

A pilot study was planned using 200 trees from five populations of 20 trees from each of the two taxa. Linear discriminant and canonical variable analyses of fifteen needle and cone morphological characters (variables) were carried out. Seven variables were found to contribute significantly to a discriminant function which identified trees as belonging to one or other of the two taxa with only 3% mis-classified. A second discriminant function which used only easily measurable (non-microscopic) variables was calculated; this separated the two taxa with the proportion mis-classified increasing to 9.5%.

Canonical variable analysis using the same variables as in the first discriminant function confirmed the presence of two classes (species) and showed that *P. patula* ssp. *tecunumanii* is a much more variable taxon than *P. oocarpa*.

Data from further provenances of disputed identity were then included in the analyses. These showed that the following provenances in the CFI International Provenance Trials of *P. oocarpa* are in fact *P. patula* ssp. *tecunumanii*: Mountain Pine Ridge, Belize; San Rafael, Yucul and Las Camellias, Nicaragua. Mexican provenances of *P. oocarpa* to which the varietal name *ochoterenae* Martínez is attached are also clearly classified as *P. patula* ssp. *tecunumanii*.

Finally analysis of data from two provenances of *P. patula* are presented. This suggests that the citation of the Tecun Umán Pine as being a subspecies of *P. patula* is correct.

**RÉSUMÉ**


**RESUMEN**

Analisis discriminante lineal y analisis de variables canonicas con combinaciones diferentes de caracteristicas morfológicos escogio entre *Pinus oocarpa* Schiede y *P. patula* Schiede and Deppe ssp. *tecunumanii* (Eguiluz and Perry) Styles. Los resultados mostraron que algunas procedencias, entre ellas Mountain Pine Ridge, Belize; Yucul, San Rafael y Las Camellias, Nicaragua, en los ensayos internacionales de *P. oocarpa*, son realmente *P. patula* ssp. *tecunumanii*.

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Introduction and Taxonomic History

The investigation and collection of seed of known provenances of Central American pine species by Research Staff at the CFI and the results from its subsequent and continuing evaluation in International Provenance Trials have been widely reported (see e.g. Kemp, 1973; Greaves, 1980; Gibson, 1982; Stead, 1983). Over the last three years, attention has focussed on a comparatively little known taxon of the closed cone pine group (sensu Little and Critchfield, 1969; Barnes and Styles, 1983): *Pinus patula* Schiede and Deppe subspecies *tecunumanii* (Eguiluz and Perry) Styles.

This species was first described by Schwerdtfeger (1953) as *P. tecum­umanii* Schwerdtfeger, but since he failed to provide a Latin diagnosis and to designate a holotype, both required by the International Code of Botanical Nomenclature (1983), this name is illegitimate. Other workers considered the taxon to be no more than a deviant form of *P. oocarpa* (Standley and Steyermark, 1958) or a variety of it, *P. oocarpa* var. *tecumumanii* (Aguilar, 1962; Mittak, 1977). Eguiluz and Perry (1983) studied Schwerdtfeger’s pine in greater detail in Guatemala and concluded that it was a distinct species. Their specific name (with a slight change of spelling of the epithet) *P. tecunumanii* Eguiluz and Perry, is legitimate. More recently, Styles (1985) has presented evidence to support his long-held view that this taxon is a subspecies and a southerly extension of the natural range of *P. patula*. His citation, *P. patula* ssp. *tecunumanii*, has been used throughout this paper. A full botanical and ecological description of the subspecies can be found in the texts of Eguiluz and Perry (op. cit.) and of Styles (1985 and 1986).

Until about 1980, the taxon had been described from only a few sites in upland Guatemala. At around this time, however, it was becoming evident that several provenances of *P. oocarpa* in the International Provenance Trials were performing consistently better than all other provenances at almost every site (Greaves, 1982). Trees from these provenances could often be identified by simple observation of their growth, form and habit. They were reported to be very similar to *P. patula*, having the red flaky papery bark on the upper stem so typical of that species (Gibson, Barnes pers. comm. 1).

It was thus postulated that some of the *P. oocarpa* provenances were in fact Schwerdtfeger’s Tecun Umán pine *i.e. P. patula* ssp. *tecunumanii*.

The excellent growth and form of these provenances in trials prompted the intensive programme of exploration and seed collection of *P. patula* ssp. *tecunumanii* in its natural range with the result that the CFI now has seed, resin and botanical specimens from over twenty provenances.

The problem of the identification of *P. patula* ssp. *tecunumanii*

During the exploration and seed collection phases of this work there have been frequent problems with the field identification of the species, especially in distinguishing it from *P. oocarpa* (McCarter, 1984). The problem is not new. Stead (1981) has pointed out that the genus, as a whole, does not easily lend itself to traditional qualitative descriptions which would enable species to be keyed out accurately in terms of, for example, general needle or cone morphology. Even within a fairly limited area many characters are so extremely variable that the ranges of different species overlap considerably. The problem is acute when dealing with closely related species and even more so when there is a likelihood of hybridisation (see e.g. Styles et al., 1982). Site quality also plays a role in confusing the situation (McCarter, 1985). *P. oocarpa* on its typical very poor, dry sites and *P. patula* ssp. *tecunumanii* on its more typical fertile moist sites do not present

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identification problems. In mixed stands, however, on sites which are good for *P. oocarpa* and less than optimal for *P. patula ssp. tecunumanii* the two taxa can appear, even on close examination, confusingly similar. Occasionally the identity of a pure stand of one or the other can be uncertain.

Using traditional qualitative descriptions, the separation on morphological characters of the two taxa should be a straightforward matter. For example, *P. oocarpa* is reputedly a five-needled species, whilst *P. patula ssp. tecunumanii* is mainly four-needled (with a proportion of fascicles with three or five needles). The needles of *P. oocarpa* are described as broad and stiff, with scaly black sheaths whilst those of *P. patula ssp. tecunumanii* are slender and pendulous or spreading, with slender smooth sheaths. The bark of *P. oocarpa* is thick, greyish-black and plated; that of *P. patula ssp. tecunumanii* is reddish and flaky. Their cones are of different geometry: those of *P. oocarpa* are as broad as they are long, with a flattened base, compared with the narrowly conoidal *P. patula ssp. tecunumanii* cones which have a pointed apex and a rounded base (Styles, 1976 and 1985). Nevertheless, trees are often misidentified in the forest because these botanical characteristics are so extremely variable.

The one diagnostic character which is generally accepted as being almost invariable, is the position of the resin canals in a cross-section of the needle. Almost all *P. oocarpa* needle sections show one or more septal resin canals, unlike almost all *P. patula ssp. tecunumanii* needle sections, which have medial resin canals. This characteristic is qualified because occasionally, a needle section of *P. oocarpa* will show no septal resin canals (<3%), and also, much less frequently, a needle section of *P. patula ssp. tecunumanii* will have perhaps a single medial resin canal (<0.2%) (McCarter, unpublished data).

**Methods for separating the taxa**

Given the problems of using these qualitative descriptions to separate the two taxa, it was decided that a numerical approach could be more useful. Such techniques have been successfully used to elucidate taxonomic problems within the genus *Pinus*. As a result of his multivariate study of the *P. chiapensis/P. monticola/P. strobus* group, Andresen (1966) was able to suggest that the former species, originally described as a variety of *P. strobus*, should be elevated to specific rank. The existence of hybrids between *P. caribaea* Mor. var. *hondurensis* (Senecl.) Barr. and Golf. and *P. oocarpa* in natural stands of the species in Honduras was demonstrated by use of canonical correlation analysis (Styles et al., 1982). Stead (1981) made a revision to the *P. pseudostrobus* complex by using a combination of principal components analysis and canonical discriminant analysis.

Measuring the characteristics routinely used by pine taxonomists (about 20 in the above studies) is a lengthy (over two hours per specimen) and often tedious process — especially those which involve microscopic work. Commonsense and the experience of previous workers suggested that, depending on the problem under examination, a much smaller number of characteristics is all that is required to elucidate the problem.

It was thus decided to carry out a pilot study aimed at identifying the characters which in this particular case aided discrimination between *P. oocarpa* and *P. patula ssp. tecunumanii*.

**Method**

For the pilot study, 10 populations of 20 trees each were measured. These populations, together with basic site data are listed in Table 1. The characteristics measured are detailed in Table 2. The needle characteristics were assessed on mature needles, using ten separate fascicles from each tree and the cone characteristics on two fully opened cones. These
### Table 1
Basic site data for populations used in pilot study

<table>
<thead>
<tr>
<th>Population, Country</th>
<th>Computer code</th>
<th>Latitude (° North)</th>
<th>Longitude (° West)</th>
<th>Altitude (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. patula ssp. tecunumanii</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yucul, Nicaragua</td>
<td>YUCUL</td>
<td>12°55'</td>
<td>85°47'</td>
<td>900</td>
</tr>
<tr>
<td>La Paz, Honduras</td>
<td>LAPAZ</td>
<td>14°19'</td>
<td>87°45'</td>
<td>1850</td>
</tr>
<tr>
<td>Culmi, Honduras</td>
<td>CULMI</td>
<td>15°10'</td>
<td>85°20'</td>
<td>600</td>
</tr>
<tr>
<td>Villa Santa, Honduras</td>
<td>VSTEC</td>
<td>14°11'</td>
<td>86°20'</td>
<td>900</td>
</tr>
<tr>
<td>Guajiquiro, Honduras</td>
<td>GUAIJI</td>
<td>14°11'</td>
<td>87°50'</td>
<td>2200</td>
</tr>
<tr>
<td><em>P. oocarpa</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>San Juan, Honduras</td>
<td>SANJU</td>
<td>14°24'</td>
<td>88°23'</td>
<td>1300</td>
</tr>
<tr>
<td>Villa Santa, Honduras</td>
<td>VSOOC</td>
<td>14°12'</td>
<td>86°25'</td>
<td>900</td>
</tr>
<tr>
<td>La Lagunilla, Guatemala</td>
<td>LAGUN</td>
<td>14°42'</td>
<td>89°57'</td>
<td>1600</td>
</tr>
<tr>
<td>Zamorano, Honduras</td>
<td>ZAMOR</td>
<td>14°02'</td>
<td>87°03'</td>
<td>1350</td>
</tr>
<tr>
<td>Dipilto, Nicaragua</td>
<td>DIPIL</td>
<td>13°43'</td>
<td>86°32'</td>
<td>1100</td>
</tr>
</tbody>
</table>

### Table 2
Morphological characteristics assessed on all needle and cone specimens

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of needle (cm to nearest mm)</td>
<td>NLTH</td>
</tr>
<tr>
<td>Width of needle (mm x 40)</td>
<td>NWTH</td>
</tr>
<tr>
<td>Number of needles per fascicle</td>
<td>LVES</td>
</tr>
<tr>
<td>Length of sheath (mm to nearest mm)</td>
<td>SHTH</td>
</tr>
<tr>
<td>Number of stomatal lines on dorsal surface</td>
<td>SLDI</td>
</tr>
<tr>
<td>Number of stomatal lines on ventral surface</td>
<td>SLVE</td>
</tr>
<tr>
<td>Number of stomata per 5 mm line on dorsal surface</td>
<td>STOM</td>
</tr>
<tr>
<td>Number of marginal serrations per 5 mm</td>
<td>SERR</td>
</tr>
<tr>
<td>Number of resin canals (total)</td>
<td>RCAN</td>
</tr>
<tr>
<td>Number of septal resin canals</td>
<td>RCSP</td>
</tr>
<tr>
<td>Length of cone (cm to nearest mm)</td>
<td>CLTH</td>
</tr>
<tr>
<td>Width of cone at widest point (cm to nearest mm)</td>
<td>WTH1</td>
</tr>
<tr>
<td>Width of cone at right angles to WTH1 (cm to nearest mm)</td>
<td>WTH2</td>
</tr>
<tr>
<td>Width of umbo (mm to nearest 0.5 mm)</td>
<td>UMBO</td>
</tr>
<tr>
<td>Width of apophysis (mm to nearest 0.5 mm)</td>
<td>WAPO</td>
</tr>
<tr>
<td>Depth of apophysis (mm to nearest 0.5 mm)</td>
<td>DAPO</td>
</tr>
<tr>
<td>Length of peduncle (mm to nearest mm)</td>
<td>PEDL</td>
</tr>
</tbody>
</table>
Table 3
Provenance mean values for the needle characteristics

<table>
<thead>
<tr>
<th>Prov.</th>
<th>NLTH</th>
<th>NWTH</th>
<th>LVES</th>
<th>SHTH</th>
<th>SLDO</th>
<th>SLVE</th>
<th>STOM</th>
<th>SERR</th>
<th>RCAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAPAZ</td>
<td>16.4</td>
<td>36.7</td>
<td>4.5</td>
<td>12.6</td>
<td>5.4</td>
<td>7.5</td>
<td>60.3</td>
<td>29.9</td>
<td>2.8</td>
</tr>
<tr>
<td>CULMI</td>
<td>18.4</td>
<td>37.0</td>
<td>4.1</td>
<td>10.7</td>
<td>5.7</td>
<td>7.2</td>
<td>54.1</td>
<td>26.3</td>
<td>2.5</td>
</tr>
<tr>
<td>VSTEC</td>
<td>18.6</td>
<td>38.0</td>
<td>4.5</td>
<td>13.5</td>
<td>5.8</td>
<td>8.4</td>
<td>54.3</td>
<td>27.6</td>
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</tr>
<tr>
<td>YUCUL</td>
<td>17.5</td>
<td>38.6</td>
<td>4.1</td>
<td>13.1</td>
<td>5.3</td>
<td>7.2</td>
<td>52.6</td>
<td>23.1</td>
<td>2.2</td>
</tr>
<tr>
<td>GUAJI</td>
<td>16.1</td>
<td>38.2</td>
<td>4.5</td>
<td>14.0</td>
<td>5.9</td>
<td>7.9</td>
<td>58.8</td>
<td>28.1</td>
<td>2.7</td>
</tr>
<tr>
<td>SANJU</td>
<td>19.7</td>
<td>41.6</td>
<td>4.8</td>
<td>14.8</td>
<td>5.7</td>
<td>9.1</td>
<td>47.2</td>
<td>21.3</td>
<td>4.3</td>
</tr>
<tr>
<td>VSOOC</td>
<td>20.3</td>
<td>38.5</td>
<td>4.7</td>
<td>16.1</td>
<td>5.7</td>
<td>8.7</td>
<td>49.4</td>
<td>22.8</td>
<td>4.0</td>
</tr>
<tr>
<td>LAGUN</td>
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<td>38.6</td>
<td>4.9</td>
<td>18.1</td>
<td>5.4</td>
<td>8.5</td>
<td>50.7</td>
<td>23.4</td>
<td>4.4</td>
</tr>
<tr>
<td>ZAMOR</td>
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<td>40.3</td>
<td>4.9</td>
<td>17.6</td>
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<td>8.9</td>
<td>45.6</td>
<td>19.9</td>
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<tr>
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<td>41.8</td>
<td>4.8</td>
<td>16.0</td>
<td>6.5</td>
<td>9.7</td>
<td>47.0</td>
<td>22.0</td>
<td>4.8</td>
</tr>
<tr>
<td>S.E. (mean)</td>
<td>6.3</td>
<td>10.1</td>
<td>1.0</td>
<td>5.6</td>
<td>2.6</td>
<td>3.2</td>
<td>12.9</td>
<td>12.7</td>
<td>2.9</td>
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</table>

Provenance mean values for the cone characteristics

<table>
<thead>
<tr>
<th>Prov.</th>
<th>CLTH</th>
<th>WTHM</th>
<th>WAPO</th>
<th>DAPO</th>
<th>UMBO</th>
<th>PEDL</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAPAZ</td>
<td>6.5</td>
<td>5.7</td>
<td>11.8</td>
<td>7.3</td>
<td>4.2</td>
<td>2.1</td>
</tr>
<tr>
<td>CULMI</td>
<td>5.7</td>
<td>5.5</td>
<td>11.3</td>
<td>7.5</td>
<td>3.7</td>
<td>2.1</td>
</tr>
<tr>
<td>VSTEC</td>
<td>6.0</td>
<td>5.7</td>
<td>10.5</td>
<td>6.8</td>
<td>3.6</td>
<td>2.1</td>
</tr>
<tr>
<td>YUCUL</td>
<td>5.0</td>
<td>4.9</td>
<td>9.6</td>
<td>6.5</td>
<td>3.7</td>
<td>1.7</td>
</tr>
<tr>
<td>GUAJI</td>
<td>6.8</td>
<td>5.2</td>
<td>11.2</td>
<td>7.4</td>
<td>3.8</td>
<td>1.8</td>
</tr>
<tr>
<td>SANJU</td>
<td>5.6</td>
<td>5.9</td>
<td>11.0</td>
<td>7.7</td>
<td>3.9</td>
<td>2.3</td>
</tr>
<tr>
<td>VSOOC</td>
<td>5.9</td>
<td>5.9</td>
<td>10.7</td>
<td>7.1</td>
<td>3.7</td>
<td>2.4</td>
</tr>
<tr>
<td>LAGUN</td>
<td>6.2</td>
<td>6.6</td>
<td>11.8</td>
<td>8.2</td>
<td>4.3</td>
<td>2.1</td>
</tr>
<tr>
<td>ZAMOR</td>
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<td>11.7</td>
<td>7.8</td>
<td>3.7</td>
<td>2.5</td>
</tr>
<tr>
<td>DIPIL</td>
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<td>6.0</td>
<td>11.7</td>
<td>7.7</td>
<td>4.2</td>
<td>2.4</td>
</tr>
<tr>
<td>S.E. (mean)</td>
<td>3.0</td>
<td>2.3</td>
<td>4.1</td>
<td>3.1</td>
<td>1.4</td>
<td>1.2</td>
</tr>
</tbody>
</table>

are taken routinely from trees from which seed is collected. Tree mean values are used in the analyses as this study was concerned with between tree variation, not within tree variation.

Table 3 shows for each provenance the mean values of the 15 characteristics of interest (to be referred to as variables). The mean value of the two perpendicular cone widths (WTHM) was used because, being highly correlated there was no advantage in using them both. Nor was there any evidence of asymmetry in the cones.
The multivariate method of analysis selected was the linear discriminant function. A criterion, independent of the measured characteristics, is used to separate the members of the sample into one of two classes. Here the presence or absence of septal resin canals was used to identify a tree as belonging to *P. patula* ssp. *tecunumanii* or *P. oocarpa*. Five populations were *P. oocarpa* and five, *P. patula* ssp. *tecunumanii* (i.e. septal resin canals = *P. oocarpa*). Univariate analyses of variance showed highly significant differences both between the two species and between provenances within each species for most variables (Table 4). The discriminant function attempts to reproduce this allocation using the value of $Y$, a linear combination of some or all of the variables (in Table 2) measured on each member of the sample ($X_1, X_2 \ldots X_{15}$)

$$Y = a_0 + a_1X_1 + a_2X_2 + \ldots + a_{15}X_{15}$$
In order to discriminate clearly between the classes it is necessary that the mean values of Y for each class are well separated compared with the variation of Y within the classes. The discriminant function is calculated by maximising the ratio of the difference in Y between the classes to the variance of Y within the classes. The constant $a_0$ is here defined so that the overall mean of Y is O. The rule for allocating individuals to the classes is:

if $Y > 0$ individual belongs to class 1
if $Y < 0$ individual belongs to class 2

Because the variables were the means of several samples from the same tree, they were regarded as continuous and as having an approximately multivariate normal distribution. There were no missing values.

The objective was to find a discriminant function with a high probability of correctly predicting the species to which a tree belongs, and to identify the variables that made a significant contribution to the discrimination. A further objective was to find a discriminant function that could be used in the forest to help identify a tree. This function would be based on variables that are easily measured in the field viz. NLTH, LVES, STHH, CLTH, WTHM and PEDL. It would not be the optimal discriminant function, but hopefully would identify a tree with a high probability of being correct.

A discriminant function was calculated using the 15 variables; nine variables did not make a significant contribution. Table 5 shows the t-test for the contribution of each variable when the other 14 variables were in the discriminant function.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Analysis 1</th>
<th>Analysis 2</th>
<th>Analysis 3</th>
<th>Analysis 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLTH</td>
<td>-1.7NS</td>
<td>-1.4NS</td>
<td>-3.4**</td>
<td></td>
</tr>
<tr>
<td>NWTH</td>
<td>-1.4NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LVES</td>
<td>-3.0**</td>
<td>-4.0***</td>
<td>-3.5***</td>
<td>-4.4***</td>
</tr>
<tr>
<td>STHH</td>
<td>-4.0***</td>
<td>-3.6***</td>
<td>-5.6***</td>
<td>-4.4***</td>
</tr>
<tr>
<td>SLDO</td>
<td>1.0NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SLVE</td>
<td>-0.4NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STOM</td>
<td>4.1***</td>
<td>6.0***</td>
<td>5.9***</td>
<td></td>
</tr>
<tr>
<td>SERR</td>
<td>-0.1NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCAN</td>
<td>-7.0***</td>
<td>-7.5***</td>
<td>-8.7***</td>
<td></td>
</tr>
<tr>
<td>CLTH</td>
<td>3.4***</td>
<td>3.4***</td>
<td>4.4***</td>
<td>4.9***</td>
</tr>
<tr>
<td>WTHM</td>
<td>-2.4**</td>
<td>-2.3*</td>
<td>-2.8**</td>
<td>-4.3***</td>
</tr>
<tr>
<td>WAPO</td>
<td>1.6NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAPO</td>
<td>-1.3NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UMBO</td>
<td>-0.8NS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEDL</td>
<td>-3.2**</td>
<td>-1.8NS</td>
<td>-3.6***</td>
<td>-2.1**</td>
</tr>
</tbody>
</table>

Different combinations of variables produce different linear discriminant functions. The t-value tests the significance of the contribution of each variable to these functions. Analyses 1 and 2 refer to preliminary investigations, analyses 3 and 4 to discriminant functions I and II respectively.

***P < .001  **.001 < P < .01  *.01 < P < .05  NS not significant
These results show that all the easily measured variables have significant t-values except for NLTH. However, the contribution of a variable to a discriminant function will alter when the calculation is done with a different set of variables. Therefore it is not always necessary to drop a non-significant variable. The discriminant function was recalculated with eight variables, NLTH, LVES, SHTH, STOM, RCAN, CLTH, WTHM and PEDL. The t-values are shown in column 2 of Table 5. NLTH alone is still not significant, and was omitted from the next calculation (column 3).

The discriminant function is:

\[ Y = 4.91 - 0.83 \text{LVES} - 0.2 \text{SHTH} + 0.10 \text{STOM} - 0.61 \text{RCAN} + 0.50 \text{CLTH} - 0.42 \text{WTHM} - 0.74 \text{PEDL} \]  

If \( Y > 1 \) classify the tree as *P. patula* ssp. *tecunumanii*  
If \( Y < 1 \) classify the tree as *P. oocarpa*

Discriminant function I is successful in allocating the trees to the correct species. The number of trees mis-allocated is six (see Table 6). These are the same trees mis-allocated using the discriminant function with 15 variables. The provenances to which the mis-allocated trees belong are shown in Table 7.

The proportion of individuals mis-allocated is smallest for the actual sample used to calculate the discriminant function I. Other samples, identified with this particular discriminant function will generally have a slightly larger proportion of mis-allocated individuals.

<table>
<thead>
<tr>
<th>Final taxon</th>
<th>TEC</th>
<th>OOC</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original taxon</td>
<td>TEC</td>
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<td>3</td>
</tr>
<tr>
<td>OOC</td>
<td>3</td>
<td>97</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>99</td>
<td>100</td>
<td>199</td>
</tr>
</tbody>
</table>

Proportion mis-allocated = 3%

<table>
<thead>
<tr>
<th>Final taxon</th>
<th>TEC</th>
<th>OOC</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original taxon</td>
<td>TEC</td>
<td>90</td>
<td>9</td>
</tr>
<tr>
<td>OOC</td>
<td>10</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>99</td>
<td>199</td>
</tr>
</tbody>
</table>

Proportion mis-allocated = 9.5%

### Table 6
Allocation to the two taxon by linear discriminant function

<table>
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<tr>
<th>Linear discriminant function I</th>
<th>Final taxon</th>
<th>TEC</th>
<th>OOC</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original taxon</td>
<td>TEC</td>
<td>96</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>OOC</td>
<td>3</td>
<td>97</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>99</td>
<td>100</td>
<td>199</td>
<td></td>
</tr>
</tbody>
</table>

Proportion mis-allocated = 3%

<table>
<thead>
<tr>
<th>Linear discriminant function II</th>
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<th>TEC</th>
<th>OOC</th>
<th>Total</th>
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<td>Original taxon</td>
<td>TEC</td>
<td>90</td>
<td>9</td>
<td>99</td>
</tr>
<tr>
<td>OOC</td>
<td>10</td>
<td>90</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>99</td>
<td>199</td>
<td></td>
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</tbody>
</table>

Proportion mis-allocated = 9.5%

### Table 7
The distribution by provenance of trees mis-allocated by the different discriminant functions

<table>
<thead>
<tr>
<th>LAPAZ</th>
<th>CULMI</th>
<th>VSTEC</th>
<th>YUCUL</th>
<th>GUAJI</th>
<th>SANJU</th>
<th>VSOOC</th>
<th>LAGUN</th>
<th>ZAMOR</th>
<th>DIPIL</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>II</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>
A canonical variables analysis was carried out using the seven variables, LVES, SHTH, STOM, RCAN, CLTH, WTHM and PEDL, and treating the ten provenances as ten classes. This was to investigate the relationship between the provenances. Canonical variables are linear combinations of the original variables that maximise the variation between classes relative to the variation within classes. The first canonical variable shows the maximum ratio of between to within class variation. Subsequent canonical variables must be uncorrelated with previous ones. The discriminant analysis is a special case of
Diagram 1. Plot of canonical variables showing the mean and range of individual trees from each of the ten provenances used in the Pilot Study. Variables used in this analysis were: LVES, SHTH, STOM, RCAN, CLTH, WTHM and PEDL. (........ P. oocarpa; ------- P. patula ssp. tecunumanii).

Diagram 2. Plot of canonical variables showing provenance mean values and the ranges of the two taxa. Variables used were: NLTH, LVES, SHTH, CLTH, WTHM and PEDL.
canonical variables analysis when there are only two classes and therefore only one canonical variable, which is the linear discriminant function.

The first canonical variable (Table 8) is very similar to the discriminant function and separates the ten provenances into the two taxa. This confirms that the original criterion for classifying a tree is the correct one.

Diagram 1 is a plot of these canonical variables, showing the mean and the spread of the individual trees for each provenance. There are significant differences between all pairs of provenances except for the following, all of which are *P. oocarpa*:

SANJU-VSOOC, SANJU-DIPIL and VSOOC-DIPIL

All five provenances of *P. oocarpa* are close together and the points for individual trees overlap considerably. The second canonical variable divides the *P. patula ssp. tecunumanii* provenances into two groups, VSTEC, YUCUL, CULMI and GUAJI, LAPAZ. This division bears a relationship to the altitudes of the provenances which are given in Table 1. The measurement of seven characteristics (LVES, SHTH, STOM, RCAN, CLTH, WTHM, PEDL) has elucidated the relationships between the original ten provenances.

The other aim of the study was to classify a tree as *P. oocarpa* or *P. patula ssp. tecunumanii* using only the six variables NLTH, LVES, SHTH, CLTH, WTHM and PEDL.

The discriminant function II, was calculated using these six variables; all made a significant contribution (Table 5).

\[
Y = 13.37 - 0.16 \text{NLTH} - 1.07 \text{LVES} - 0.24 \text{SHTH} + 0.59 \text{CLTH} - 0.68 \text{WTHM} - 0.76 \text{PEDL} \]

If \(Y > 1\) classify the tree as *P. patula ssp. tecunumanii*

If \(Y < 1\) classify the tree as *P. oocarpa*

The proportion mis-allocated was 9.5%. These are shown in Table 7. A canonical variables analysis was also calculated using these six variables. The plot of the first two canonical variables (Diagram 2) is similar to Diagram 1. The ranges of the individual trees from the two species overlap to a greater extent than in Diagram 1. There are significant differences between all pairs of provenances except for the same three pairs as previously.

This function allows one to make a reasonably accurate attempt at identifying a specimen using easily measured characteristics.

**Other provenances of disputed identity**

Having demonstrated that the two taxa, *P. oocarpa* and *P. patula ssp. tecunumanii* could be satisfactorily separated by the first discriminant function and canonical variable analysis, we next looked at several other provenances of disputed identity.

Greaves (1982) had singled out five provenances in the International Provenance Trials of *P. oocarpa* as showing exceptional promise in terms of vigour, and stem and crown form. One of these was Yucul, which we have already identified as being *P. patula ssp. tecunumanii*. The others are: Las Camelas, San Rafael, Mountain Pine Ridge and Jitotol [Jitotil, *sic*].

The provenances of Las Camelas and San Rafael, like Yucul are found in north and central Nicaragua; the sites and phenotype of the trees are very similar to Yucul, and we were expecting them to be identified as the Tecun Umán Pine. Styles (1985) has already stated that they are.

The identity of the provenance from Mountain Pine Ridge, Belize has always been a great deal more uncertain. Hunt (1964) and Lamb (1966) refer to it as *P. oocarpa* var. *ochoterenae* Martínez, whilst Styles (1976) considered it to be typical *P. oocarpa*
Table 9
Basic site data for further provenances examined

<table>
<thead>
<tr>
<th>Provenance</th>
<th>Country</th>
<th>Latitude (° North)</th>
<th>Longitude (° West)</th>
<th>Altitude (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. patula</em> ssp. <em>tecunumanii</em> / <em>P. oocarpa</em> var. <em>ochoterena</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Las Camelas, Xoxocotla, Veracruz, Nicaragua</td>
<td>13°46'</td>
<td>86°18'</td>
<td>900</td>
<td></td>
</tr>
<tr>
<td>San Rafael, Nicaragua</td>
<td>13°14'</td>
<td>86°08'</td>
<td>1200</td>
<td></td>
</tr>
<tr>
<td>Mountain Pine Ridge, Belize</td>
<td>17°00'</td>
<td>88°55'</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>Jitotol, Chiapas, Mexico</td>
<td>17°05'</td>
<td>92°30'</td>
<td>1650</td>
<td></td>
</tr>
<tr>
<td>Juquilla, Oaxaca, Mexico</td>
<td>16°15'</td>
<td>97°17'</td>
<td>2100</td>
<td></td>
</tr>
<tr>
<td><em>P. patula</em> var. <em>longopedunculata</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Llano de Flores, Oaxaca, Mexico</td>
<td>17°27'</td>
<td>96°29'</td>
<td>2800</td>
<td></td>
</tr>
<tr>
<td><em>P. patula</em> ssp. <em>patula</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xoxocotla, Veracruz, Mexico</td>
<td>18°40'</td>
<td>97°08'</td>
<td>2550</td>
<td></td>
</tr>
</tbody>
</table>

Diagram 3. The canonical variables plot is the same as Diagram 1. Also included are the mean values and ranges of two provenances of disputed identity, Mountain Pine Ridge and San Rafael. The individual tree values for the three available trees from a third provenance, Las Camelas, are also shown. (o).
as indeed does Dvorak (1985). Wolffsohn (pers. comm.\(^2\)) considered that the trees were certainly not typical \textit{P. oocarpa}, and suggested that they were similar, ecologically and silviculturally to the Culmi provenance of '\textit{P. oocarpa}' of eastern Honduras. This we have already demonstrated to be \textit{P. patula} ssp. \textit{tecunumanii}. For Barnes and Gibson (pers. comm.\(^3\)), the Mountain Pine Ridge progeny in the International Trials were the most similar to \textit{P. patula} in terms of gross morphology, although they considered it to be quite different from Yucul, in general habit. The results from our analyses would thus be of considerable interest.

No botanical material was available for the Jitotol provenance from Chiapas, Mexico. This is termed \textit{P. oocarpa} var. \textit{ochoterena} by Mexican foresters and others, although there is also undoubtedly typical \textit{P. oocarpa} at this site. Specimens were available however from another Mexican provenance: Juquila, Oaxaca, which is similarly termed \textit{P. oocarpa}

![Diagram 4](image)

Diagram 4. Plot of canonical variables of all provenances examined. Variables used were: NLTH, SHTH, LVES, RCAN, CLTH and WTHM. This shows the relationships of all the taxa examined to each other. The solid lines delimit the two main taxa, \textit{P. oocarpa} to the left, \textit{P. patula} ssp. \textit{tecunumanii} to the right, and the broken lines (left to right), \textit{P. oocarpa} var. \textit{ochoterena}, \textit{P. patula} ssp. \textit{patula} and \textit{P. patula} var. \textit{longepedunculata}.


\(^3\) R. D. Barnes and G. L. Gibson, CFI, South Parks Road, Oxford, OX1 3RB.
var. *ochoterenae*. (Basic site data for all further provenances examined are detailed in Table 9).

The samples from Las Camelas (3 trees), San Rafael (21 trees) and Mountain Pine Ridge (20 trees) were measured. Both discriminant functions I and II classified all the trees as *P. patula* ssp. *tecunumanii*. When the provenance mean values of the canonical variables are plotted (Diagram 3) they are found to lie close to the VSTEC, CULMI and YUCUL group. The sample from Juquila, OAXACA (20 trees) was also clearly identified as *P. patula* ssp. *tecunumanii*, lying between LAPAZ and GUAJI in the plot of the first two canonical variables.

Finally, material was available from two populations of *P. patula*: one typical *P. patula* (20 trees), the other, its variety longepedunculata Loock (also 20 trees). We have included plots of the provenance mean values of the canonical variables and of the limits of their variation in Diagram 4. This analysis used the following characteristics: NLTH, SHTH, LVES, RCAN, CLTH and WTHM. (Typical *P. patula* cones are largely sessile and the character PEDL was dropped).

The relationship of our provenances of the Tecun Umán Pine to those populations of *P. patula* would seem to indicate to us that the status which Styles (1985) has suggested for the taxa is correct (i.e. its relationship to *P. patula*).

**Discussion**

The basic problem we have tackled in this study had been one of classification. This has largely been a matter of placing a tree (or a population) into one of two classes: *P. oocarpa* or *P. patula* ssp. *tecunumanii*. That the name of this second class is still a matter of debate does not concern us. Of course there may be more than two classes present: see for example the canonical variable analysis of our five pilot Tecun Uman pine populations. This has demonstrated that two groups are identifiable: GUAJI and LAPAZ, and VSTEC, YUCUL and CULMI. Whether intraspecific variation can account for these differences or not, we leave in the hands of taxonomists.

We have shown that the continuities in the variation patterns of many different morphological characters within the two taxa under study are such that orthodox taxonomic methods of observing phenotype and hence distinguishing genotype are largely unsatisfactory. For those unfamiliar with the complexities and ranges of variation in natural stands of Central American Pines, the evidence that several experienced field foresters, over the period of almost a decade, unknowingly collected seed of *P. patula* ssp. *tecunumanii* along with, or at times, instead of *P. oocarpa* is surely a good indication of the difficulties faced. Nor should the fact that in the trials the two taxa are readily distinguishable be taken as any indication of poor original observation: variation of gross morphological characters of plants grown in exotic locations can and often does bear little resemblance to the variation found in their natural habitats. Rather it underlines the value of such trials in elucidating taxonomic problems.

We have touched briefly on the problem of *P. oocarpa* var. *ochoterenae*. Described by Martínez (1940), from Chiapas, Mexico, the results from our study — although somewhat limited — indicate that this is probably synonymous with *P. patula* ssp. *tecunumanii*, as first described by Schwerdtfeger from Guatemala. Interestingly, Styles (1976) before the present interest in the Tecun Umán Pine suggested that *P. oocarpa* var. *ochoterenae* should be referred to as *P. patula* var. *longepedunculata*.

The entire problem will be much more clearly illuminated when data from the remaining 10–12 populations of this taxon which are available at CFI are included in the analysis.
Conclusions

On the basis of this study the following provenances in the CFI International Provenance Trials of *P. oocarpa* should henceforth be referred to as *P. patula* ssp. *tecunumanii*:

- Yucul, Nicaragua
- Las Camelias, Nicaragua
- San Rafael, Nicaragua
- Mountain Pine Ridge, Belize.

It is also likely that the Jitotol provenance from Mexico referred to as *P. oocarpa* var. *ochoterena* is also *P. patula* ssp. *tecunumanii* although unlike the other four provenances, typical *P. oocarpa* is found in intimate mixture with it, and early seed collections from this site are likely to have included seed from both taxa.

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AN INTEGRATED SILVICULTURAL SOLUTION TO WEEDY CLIMBER PROBLEMS IN THE SOLOMON ISLANDS

By G. E. CHAPLIN*

SUMMARY
Convolvulaceous climbers in the genera Merremia and Operculina are particularly troublesome weeds in young plantations in the Solomon Islands. The comparative merits of weed control by herbicides, cattle, fire and cover crops are discussed.

The climbers require full sunlight to grow vigorously. Silvicultural practice can be varied to control light availability and hence control the climbers.

The forester can ensure that the most appropriate tree species is chosen, that vigorous stock from the nursery is spaced, planted and tended to offer the optimum chance of success.

Key words: Weed control; afforestation; convolvulaceae; climbers; Merremia; Operculina; Solomon Islands.

Introduction
Convolvulaceous climbers, three species of Merremia (M. pacifica, M. peltata, M. bracteata) and one of Operculina (O. riedeliana) are particularly troublesome weeds during the establishment phase of plantations in the Solomon Islands. This paper will consider in detail a solution to these climber problems.

Neil (1984) in a recent article in the Commonwealth Forestry Review has discussed
some aspects of the biology of these climbers, described the problem and outlined possible means of control.

An intensive survey of the established plantations throughout the Solomon Islands in 1978/79 showed that survival and form were below expectations (Miller, 1980). Maintenance was still necessary in many of the older compartments up to seven years after planting making the cost of establishment unreasonably high.

The original system of line planting (10 × 3 m) was abandoned in 1981 as it was not working. All species, with the exception of *Swietenia macrophylla*, are now planted at much closer spacing (5 or 4 × 3 m). At the same time it was recognised that control of nursery production and improved stock, combined with vigilant maintenance by hand brushing were all necessary for successful establishment (Anon, 1981). *Terminalia calamansanai*, previously an important plantation species, was dropped from the programme in part due to its sensitivity to damage by climbers (Anon, 1981) but recently limited planting has been resumed.

Since 1980 the possibilities of controlling climbers with herbicides or cultural agents such as fire, cover crops and cattle have been investigated. This research work has now been completed and the new planting regime of closer spacing has been in operation for nearly three years.

It is now appropriate to review research and plantation experience over the last three years and define an integrated system of establishment which will be both economical and effective.

**Methods of control**

Neil (1984) outlined four methods of control. Each of these is discussed in the light of experience gained from the close spacing regime.

**Herbicides**

Herbicides are potentially useful tools for climber control if used prior to plantation establishment. To date no large scale spraying has been attempted. However, the feasibility of spraying large areas of climber infested regrowth is open to serious doubt for several important reasons.

The regrowth is a mixture of pioneer tree species such as *Macaranga, Alstonia* and *Trema* which are intimately mixed with climbers at various heights. Along with the remaining debris of logging this makes effective penetration by spray operators on foot, difficult and expensive. Lines would have to be cut at regular intervals, for example spaced at 5 m. The rough topography of the sites and logging debris precludes mechanised access.

The working conditions in the Solomon Islands (high humidity and temperature) would make the wearing of desired protective clothing intolerable. The operator and safety factors make the use of herbicides an unattractive means of control.

The chemicals require a rain-free period of at least 4 to 6 hours, which can never be guaranteed. Experience gained from the trials also indicates that more than one spraying is necessary.

Most of the vegetation on the site is killed and there may be residual activity, depending on the chemicals used. As a result the top soil would be exposed to the elements. Here as elsewhere most nutrients are concentrated in the organic topsoil (Wall, 1980) and subsequent erosion would affect the site fertility, soil structure and long-term ecology. In such high rainfall areas the ground cover and as much of its diversity as possible
should be maintained through the life of any tree plantations. One of the original considerations in line planting was to maintain as much of the inter-row vegetation as possible to enhance nutrient recycling as well as reduce erosion (Thomson, 1980). Even selective removal of the climbers is considered to be undesirable. Following logging the natural regrowth should be allowed to develop and the objective should be to establish a vigorous tree crop as a contiguous development from the natural vegetation cover.

These practical difficulties of spraying large areas and the serious ecological considerations effectively rule out the use of herbicides on a large scale for the control of *Merremia* and *Opeculina* whether used before or after establishment.

There are advantages in using funds to employ local labour for work which would otherwise require the overseas costs on chemicals and equipment.

Though herbicides are not considered to be appropriate for use on a large scale they remain a potent tool for climber control in certain situations, e.g. on roadsides and in log yards where mechanisation with tractor spraying is possible. Such areas would be continual sources of climber reinvasion into the plantations and could be effectively and usefully controlled with herbicides. Control of climbers in seed stands, which may have a low stocking, might be considered. Cover crops could be established in limited areas such as these.

**Cattle**

Cattle relish *Merremia* spp. Combined with manual brush cutting of the woody regrowth after logging they will effectively clear an area of climbers by grazing and trampling of the climber stolons. A suitable herd of steers would need to be held on regular pasture and even if some control were obtainable, in practice some areas would be inadequately cleared requiring back-up alternative methods. Trampling can cause compaction, the cattle require fencing and watering and erosion can be initiated if too much soil is exposed and disturbed.

**Fire**

The climbers are sensitive to fire and following manual brush cutting or herbicide spraying to desiccate the vegetation, small areas can be burnt and the climbers killed outright. However, appropriate dry periods are not predictable and when fires can be used they may become too fierce to control.

As with the application of herbicides and the heavy grazing that cattle imply, extensive burning brings with it the same ecological objection of massive site disturbance. Wholesale disturbance is likely to result in soil degradation through loss of nutrients and top soil. The effects on other vegetation besides *Merremia* and *Opeculina* would be equally destructive.

**Cover crops**

Various cover crops have been tested; *Pueraria phaseoloides, Centrosema pubescens, Calopogonium mucunoides, Desmodium* spp. None of these cover crops were vigorous enough to overcome and dominate *Merremia* and *Opeculina* by direct competition. However, in theory, potentially serious problems of erosion could be avoided by the use of cover crops once climbers have been removed by other means.

At the same time the cover crop would prevent climber recolonisation. Unfortunately,
there is no effective and acceptable way of clearing the climbers from large areas. Some species, such as *Pueraria phaseoloides*, are themselves aggressive climbers.

It has been suggested that some of the pioneer tree species such as *Macaranga* could be used to shade out the climbers but this is not considered to be practicable because of the difficulties and expense involved in establishing an even and close canopy.

*Merremia* and *Operculina* are themselves effective cover crops. After logging, exposed areas are rapidly colonised, the soil protected and no doubt these climbers, as part of the recolonising vegetation, contribute to site recovery after logging (Wall, 1980).

**Spacing**

Line planting at $10 \times 3$ m was finally abandoned in 1981 following Miller’s Permanent Inventory Plot (PIP) assessments (Miller, 1980; Anon., 1981). This survey revealed that survival and form were below expectations. More importantly, there was no indication that the maintenance requirements scheduled for the first six years after planting could be ended (Thomson, 1980).

Dawkins (1958) defined the criteria for successful line planting and this became the basis for the programme adopted in the Solomon Islands (Marten, 1978). However, the convolvulaceous climbers present in the Solomon Islands are so vigorous that any system of establishment which allows them to continue to thrive in the inter-rows, thus enabling them to over-arch and smother the crop, is not viable (Thomson, 1980).

With the exception of *Swietenia macrophylla* much closer spacings were adopted in 1981; $5 \times 3$ m for *Campnosperma brevipeptiolata* and *Terminalia brassii* and $4 \times 3$ m for *Gmelina arborea*. With the close spacing used for these species the tendency is to complete weeding with an insignificant inter-row. *S. macrophylla* is still planted at the previous spacing of $10 \times 3$ m. The wide inter-row is maintained to minimise risk of attack by the shoot borer *Hypsipyla robusta* and delay crown opening.

Since 1981 the new spacings have demonstrated that *G. arborea* will close canopy in two years and *T. brassii* at between two and three years. This is satisfactory, but *C. brevipeptiolata* taking 4 years is too slow and quicker canopy closure will require a spacing of $4 \times 3$ m. *T. calamansanai*, which is now being planted again at $5 \times 3$ m on a small scale, is expected to close canopy at about three years (Pollard, 1984). These periods up to canopy closure and site capture are acceptable in terms of cost of plantation establishment, the major part of which is hand weeding.

*S. macrophylla* with the wider spacing and slow crown development may take up to ten years to close canopy. The possibilities of using a nurse tree species or a tall cover crop such as *Calliandra calothyrsus* are being considered (Pollard, 1984).

**Discussion: An integrated silvicultural solution**

It is proposed that the only way to establish plantations effectively and economically is to adopt an integrated silvicultural strategy to overcome these vigorous climbers in the early life of plantations.

*Merremia* and *Operculina* require full sunlight to grow vigorously. After logging they rapidly colonise any areas where there is high light intensity at ground level. Their intolerance of shade is a weak point which can be exploited in order to overcome these weeds. A combination of seven silvicultural options and practices is outlined which from current experience seems to be essential for successful establishment.

(i) Choice of species is a critical factor totally under management control. Species with a dense crown in youth such as *G. arborea*, *T. brassii* and the promising *Acacia*
mangium are preferred. C. brevipetiolata which has slow crown development with relatively few, large, coarse leaves is unsuitable in areas of heavy climber infestation. This species has a coarse form under certain conditions and is susceptible to attack by the coreid Amblypelta cocophaga (Bigger, 1982). However experience with this native species (over seven thousand hectares have been planted), has demonstrated its ability to grow through light climber growth. Another advantage is its site tolerance. The form is also much better at close spacing in research plots. Whatever species are chosen they must be able to dominate the site within 2 to 3 years, be suited to Solomon Islands conditions and be appropriate to the aims of the planting programme, the main objective of which is sawlog production (Anon, 1981).

(ii) The second requirement is to match the species to the site. Sufficient attention must be given to pre-planting site surveys and species/site matching (Thomson, 1979).

(iii) To take advantage of such planning the third factor is control of nursery production, suitably programmed to provide the required species at the right time with the appropriate root/shoot ratio. To a large degree this will depend on control of seed supply. Previously the planting programme was dependent on wildings (natural regeneration from the logged areas transplanted to the nurseries), and as a result there was little control of species production.

(iv) The vigour of the nursery stock is a critical consideration. Since 1981 most of the planting stock has been raised as containerised plants from seed and this has resulted in improved quality and uniformity. Rigorous culling of nursery stock will be necessary to ensure the best possible planting stock. Vigorous early growth and a high survival rate are essential.

(v) The effect of spacing on the management and development of the crop is critical. Current spacings are effective at establishing canopy closure and site dominance within 2 to 3 years. The radical difference in the closer spacing regimes means that the plantations established since 1981 will require particular attention to thinning strategy. It has always been recognised that there is a very limited market for any intermediate yields (Marten, 1978). Current practice is to carry out non-productive re-spacement and early thinning operations (Anon, 1981). Immediately after site capture at canopy closure the climbers are shaded out. It remains to be seen if the climbers can re-establish themselves after thinning or as the crop matures. Past experience and present indications are that they will not become a significant threat. After early thinnings the tree canopy will respond faster and as the crop matures the climbers will in any case be a less critical threat. However, they will never be eliminated from the plantations as their woody stems remain quiescent in the deep shade of the natural forest for long periods. There will be a need to develop a market for the regular thinnings which the desired closer spacing will make available.

(vi) The sixth factor is the method of planting which must ensure good survival and rapid early growth. Application of fertilisers at establishment may be necessary.

(vii) Finally, the standard of early tending by hand brushing with bush knives to ensure a high survival rate and to encourage vigorous early growth, will need to be closely supervised to secure complete and rapid canopy closure. This factor is very largely dependent on management control and field supervision. As has already been noted by Wood and Watt (1982), stocking in the older plantations is often extremely good close to roads but becomes gradually poorer further from supervision.

Once the canopy has closed there are further opportunities to control the climbers. Road sides and log yards are often heavily infested by climbers. Such areas are accessible and can be easily controlled with herbicides. Old growth trees left after logging and which
have subsequently been poisoned before establishment of plantations often develop large climber tangles or climber towers. These could be controlled by base cutting of the climber stems. It should therefore be possible to reduce the incidence of the climbers throughout the plantations which will reduce their impact on the second rotation.

The banyans, *Ficus* spp., left after logging should also be cut or burnt down before establishment wherever possible as they are major sources of climber seed and regrowth within the plantations (Neil, 1984).

**Conclusion**

The technical package which has been outlined as an integrated approach to the silvicultural control of these vigorous convolvulaceous climbers is made up of a combination of silvicultural options and management applications.

The practice of line planting or enrichment planting requires sensitive manipulation of three factors; the forest matrix that remains after logging, the growing crop and the inter-row vegetation. Although enrichment planting appeared attractive, it has in fact proved to be impracticable under Solomon Islands conditions (Anon, 1981; Thomson, 1980). Indeed this recent experience in the Solomon Islands reflects a general trend. Catinot (1969) concluded that enrichment planting had generally given unsatisfactory results, the trend throughout the tropics has been towards the establishment of closely spaced plantations.

Unfortunately, despite all of the work that has been done with herbicides and the cultural agents (cattle, fire and cover crops), no easy means of controlling *Merremia* and *Operculina* has been identified. Despite earlier optimistic hopes (Bacon, 1981; Neil, 1984; Terry, 1981) the above approaches, singly or in combination, have only limited roles to play in climber control and none can be seen as a viable method for use in large scale plantation establishment.

The proposed technical package, which has essentially been in operation since 1981, is establishing plantations effectively and economically (Pollard, 1984). It is further suggested that under prevailing conditions of management expertise, close planting (which quickly dominates and controls the site), followed by well defined prescribed silvicultural operations of tending and thinning is the most appropriate approach for conditions in the Solomon Islands. Success is dependent on the quality of management and supervision in the field. However, the proposed solution is far less dependent on the high quality management and the supervision of elegant silvicultural practices which were a feature of the previous line planting regimes.

Further work is recommended on survival, growth, yield, silviculture and economic performance.

Such intensive silviculture will certainly be more costly initially. However, maintenance to crown closure will be vastly reduced, the long-term maintenance, which was a feature of the previous spacing regime, is virtually eliminated. The establishment of the crops should be more complete and much cheaper.

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CONTROLLED ATMOSPHERE STORAGE FOR
PINUS RADIATA SEED

By K. B. SHRESTHA*, K. R. SHEPHERD* and J. W. TURNBULL #

SUMMARY

Emphasis given to man-made forestry and artificial regeneration has focussed attention on proper seed storage but reliance has tended to be placed on sophisticated rather than simple methods. The paper describes the use of laminated plastic bags in which seeds were sealed for storage in a vacuum, in air, carbon dioxide, and in nitrogen, and kept at four temperatures ranging from 5 to 35°C for up to a year. Germination capacity and energy, and seedling vigour were best maintained by storage in nitrogen followed by carbon dioxide, a vacuum and air, irrespective of temperature. The simple and inexpensive techniques described offer effective, yet low-cost storage of forest tree seed.

RÉSUMÉ

L’accent donné à la forestrie de plantation et à la régénération artificielle a concentré l’attention sur le stockage approprié de graines mais les méthodes employées ont tendance à être sophistiquée plutôt que simples. L’article décrit l’usage de sacs en plastique laminé dans lesquels les graines sont stockées hermétiquement sous vide, avec de l’air, du dioxyde de carbone et de l’azote, et maintenues à quatre températures variant de 5 à 35°C pour jusqu’à une année. La capacité de germination et la vigueur des semis étaient maintenues le mieux par stockage avec l’azote suivit du dioxyde de carbone, du vide et de l’air, indépendamment de la température. Les techniques simples et bon marché qui sont décrites offrent la possibilité de stockage effectif et à prix réduit de graines d’arbres forestiers.

RESUMEN

Con los esfuerzos dedicados al plantaciones forestales y regeneración artificial se ha llamado la importancia de los métodos del almacenamiento efectivo de semillas. Se ha confiado en métodos sofisticados más que en métodos sencillos previamente. Se describe el uso de bolsas de plastico laminado para almacenar semillas en vacío, en aire, en bióxido de carbono y en nitrógeno y su almacenamiento subsecuente a cuatro temperaturas de 5 hasta 35°C durante periodos hasta un año. El almacenamiento en nitrógeno mantuvo mejor la capacidad de germinación, la energía y vigor de las plantulas con relación a bióxido de carbono, vacío y aire. El efecto de la temperatura no fue significativo. Los métodos sencillos descritos son baratos y efectivos para el almacenamiento de las semillas forestales.

Introduction

Most methods employed for medium- or long-term storage of seed are concerned with the control of temperature and/or seed moisture content. Appropriate storage facilities, including refrigerated rooms and dehumidified areas, are widely used in countries with

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a more advanced technology but in many developing countries seed storage has often been of a short-term nature only and of a poor standard, largely due to a lack of facilities. Often quite primitive methods have been used, such as storage in the open or underground burial in sand (Hasan 1973). The greater emphasis given to artificial regeneration in recent years has focussed attention on proper seed storage but reliance has tended to be placed on the more sophisticated techniques rather than simple and inexpensive methods. The use of refrigerated storage requires capital investment, proper maintenance and a reliable source of electricity. Unfortunately, these are not always readily available in many developing countries. In such countries, relatively simple methods of seed storage are needed which do not rely on high-cost installations or on the availability of trained maintenance staff.

Provision of seed of good physiological quality is fundamental to increasing efficiency of nursery and plantation establishment operations (Turnbull 1983). Thus the maintenance of seed germination capacity and vigour during storage is crucial for the success of many reforestation and afforestation projects. There is also a need to collect and store seed safely for use in community forestry projects in many countries where sophisticated storage facilities are not available.

In this study, relatively simple methods of controlling the seed storage atmosphere were examined. The purpose was to determine whether these methods alone could be successful in maintaining viability and vigour of orthodox tree seed without recourse to the conventional, but technologically more difficult and expensive techniques. The development of laminated plastic sheeting, almost completely impervious to moisture and gases, has made available a cheap and effective means of sealed storage. Such sealed containers have been used very effectively for the storage of rice food grains (Mitsuda and Yamamoto 1980).

The aims of the study were,

(a) to compare the effects of sealed storage atmospheres of air, carbon dioxide and nitrogen, and of a vacuum on the germinability of seeds of *P. radiata* when stored at low moisture content, and

(b) to evaluate the effects of these storage conditions for up to one year on the vigour of seedlings raised from the seed stored in controlled environment.

**Materials and Methods**

The seedlot used in the experiment was supplied by the Woods and Forests Department of South Australia from a collection made at Mt Crawford Forest Reserve in a mature plantation during the summer of 1980–81. The seedlot was cleaned meticulously by hand to remove all impurities and discoloured seed. Light weight seed was removed by means of air separation. The cleaned seedlot had a moisture content of 8.05% on a fresh weight basis using the 130°C/1 hour, oven method (ISTA 1976). The seedlot when tested initially had a germination capacity of 94.6%.

**Storage treatments**

Seeds for each treatment were divided into sub-samples and sealed in laminated plastic bags, each 11 x 11 cm. For this experiment it was essential the storage container be impervious to moisture and gases. Large laminated plastic bags, 50 cm x 80 cm, are available commercially in the food storage industry. These were cut and made into the smaller bags using a plastic heat sealer. Sample lots of four hundred seed were stored for germination testing, two hundred seed for growth tests in controlled environment.
Four storage atmospheres, air, carbon dioxide and nitrogen, and a vacuum were employed for storage. For storage in air, a seed sample was merely placed in the laminated plastic bag and it was heat sealed to ensure the bag was completely air-tight. For storage in the other two atmospheres, carbon dioxide and nitrogen, the bag was first sealed to within 2 cm of the edge of the opening, leaving sufficient room through which to pass a tube. The air in the bag was then displaced by passing the required gas through the tube from a storage cylinder before sealing the bag. Much the same procedure was followed for vacuum storage except that the air was withdrawn using a vacuum pump. Each sealed bag was placed inside a slightly larger bag and this was also sealed as a precaution against accidental puncturing of the inner bag. Replicate lots were stored at each of four temperatures 5°, 15°, 25°, and 35°C, to promote different rates of physiological ageing (Harrison 1966). A set of samples representing each storage atmosphere was withdrawn at random every five weeks for fifty weeks for germination testing, giving an experimental storage combination of 4 atmospheres × 4 temperatures × 11 time periods, including time zero. For seedling growth experiments the same procedure was followed except that the samples were withdrawn only every ten weeks. This gave an experimental storage combination of 4 atmospheres × 4 temperatures × 6 time periods, including time zero.

Germination testing

Each stored sample of 400 seeds was divided at random into 10 replicates of 40 seeds each for each germination test with the aid of a ‘Gamet’ seed divider. Approximately 5 g of fine vermiculite was spread over a 9 cm diameter petri dish and a Whatman No. 50 filter paper was placed over the top. Petri dishes prepared in this way were sterilised in an autoclave at 121°C under a pressure of 150 kPa for 30 min. The sample of 400 seeds when taken out of storage was surface sterilised in a vacuum for 5 min with 1% sodium hypochlorite solution, then washed with sterile water. A replicate of 40 seeds was spaced uniformly in each of 10 replicate dishes. Sterilised water (15 ml) was added to each dish. The dishes were covered, labelled, then placed in a closed germination cabinet. All of these preparations were carried out in a sterile room. Germination testing was carried out at a constant temperature of 20°C with 8 h of light each day, as recommended by the International Seed Testing Association (ISTA 1976). The light intensity was measured at 10 uE at the centre of the cabinet and this level of illumination was maintained throughout the experimental period. The germination test period was set initially at 28 days, following the ISTA prescription, but as a significant number of seed were still germinating, the test period was extended to 35 days. Germination counts were made daily for 28 days then on alternate days for a further 7 days. A seed was considered to have germinated when the radicle was more than 3 mm in length. Germinated seeds were recorded, then removed from the test dish.

The germination data were analysed using an analysis of variance technique. The rate of germination was expressed as the ‘coefficient of velocity’ developed by Kotowski (1926) where the numerator is the sum of daily counts and the denominator is the summation of these daily counts, each weighted by the number of days after the start of the test. A high value for the coefficient of velocity denotes an increased number of seeds germinating and a decreased time taken to germinate.

Growth testing

Each stored sample of 200 seeds was divided at random into 10 replicates of 20 each. The seeds were surface sterilised, as described above, then each replicate sown into 9 cm
pots containing a mixture of 1:1 perlite and vermiculite. The pots were labelled, watered thoroughly and placed in a controlled environment cabinet of the LB Type, as described by Morse and Evans (1962). The pots were placed upon saucers of 13 cm diameter and 1 cm deep and were watered by filling these saucers each alternate day. A commercial liquid fertiliser, 'Liquifert', was applied to the seedlings every 7 days, commencing when the test period had run for 28 days. The growth cabinets were set to provide a temperature regime of 24°C for a 12 h day and of 19°C at night with the photoperiod of 12 h corresponding to the day temperature period. This temperature regime is close to the optimum for the growth of *P. radiata* seedlings (Shepherd 1965). Light was provided by 80 watt white fluorescent tubes with an intensity at the surface of the pots of 80 μE. The growth tests were terminated after 49 days when all of the seedlings in the pot were removed and the roots washed clean of vermiculite and perlite. The seedlings in each pot were counted, placed in separate, labelled paper bags and oven dried to constant weight at 85°C for 48 h, cooled in a desiccator for at least 30 min, then weighed.

**Results and Discussion**

**Germination testing**

Seed samples stored in an atmosphere of carbon dioxide completely absorbed the gas, creating much the same effect in the bag as with a vacuum sample. This phenomenon of absorption has been reported for grain seeds such as rice, wheat and corn by Mitsuda et al. (1973). It is doubtful whether this phenomenon, as such, has any direct effect on viability and vigour of the stored seeds but it does have practical value in that the packaged seed is much more compact than with air or nitrogen storage, thus saving storage space. It would also be an advantage in packing and transporting quantities of seed.

The results show that storage atmosphere and storage temperature markedly influenced germination over the fifty week test period (Table 1). Storage in nitrogen was the best of the four treatment methods for maintaining seed viability, with carbon dioxide the next best. Loss of viability of seeds stored at 5°C was low over the 50 week test period as might be expected for seed at a low moisture content. With an increase in storage temperature the rate of loss of viability accelerated. It was most rapid when storage was in air and was delayed best by storage in nitrogen, then by carbon dioxide and vacuum storage (Table 2). The data in Table 2 are derived from the germination data over the whole of the fifty week experimental period. Although the interaction terms are significant, the values are small and of little consequence in relation to the main effects. Clearly, the storage atmosphere was of overwhelming importance in conserving germination capacity. The general mean for seed stored in nitrogen (74.18, arc-sin transformed percentage of seed sown) was significantly higher than for carbon dioxide storage (71.88), and both were significantly higher than for a vacuum (68.50) and air (68.20), which did not differ significantly. These results suggest that as the temperature rises the presence of oxygen in the storage atmosphere contributes to seed deterioration but it is not clear why seed storage in nitrogen and carbon dioxide was superior to storage in a vacuum. The general means for seed stored at 5°C (71.89) and for 15°C (71.61) did not differ significantly but were higher than for 25°C (70.68) and 35°C (68.58), in agreement with the accepted benefits of cool temperature storage of orthodox seeds at low moisture content. However, at the comparatively high storage temperature of 35°C nitrogen storage resulted in negligible loss of seed viability over the test period. Fluctuations in the germination results observed for early tests, due almost certainly to the use of a fungicide to minimise mould infection in the test dish, is thought to have
Table 1
Mean rates of germination (percentage of seed sown) after fifty weeks for *Pinus radiata* seed stored at each of four temperatures and sealed in four different storage atmospheres. Each value is the mean of ten.

<table>
<thead>
<tr>
<th>Storage atmosphere</th>
<th>Storage temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Air</td>
<td>84.2</td>
</tr>
<tr>
<td>Vacuum</td>
<td>86.4</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>90.3</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>89.5</td>
</tr>
</tbody>
</table>

Table 2
Results of analysis of variance of germination (arcsin transformed percentage of seed sown) data for the four storage atmospheres, four temperatures and eleven storage times investigated.

<table>
<thead>
<tr>
<th>Source variation</th>
<th>Degree of freedom</th>
<th>Mean squares</th>
<th>Variance ratio (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmosphere</td>
<td>3</td>
<td>3609.3</td>
<td>150.4**</td>
</tr>
<tr>
<td>Temperature</td>
<td>3</td>
<td>984.4</td>
<td>41.0**</td>
</tr>
<tr>
<td>Time</td>
<td>10</td>
<td>1110.3</td>
<td>46.2**</td>
</tr>
<tr>
<td>Atmosphere × temperature</td>
<td>9</td>
<td>86.5</td>
<td>3.6**</td>
</tr>
<tr>
<td>Atmosphere × time</td>
<td>30</td>
<td>188.5</td>
<td>7.6**</td>
</tr>
<tr>
<td>Temperature × time</td>
<td>30</td>
<td>67.3</td>
<td>2.8**</td>
</tr>
<tr>
<td>Atmosphere × temp. × time</td>
<td>90</td>
<td>30.1</td>
<td>1.2ns</td>
</tr>
<tr>
<td>Residual</td>
<td>1428</td>
<td>23.9</td>
<td></td>
</tr>
</tbody>
</table>

ns = not significant  
** = significant at p = 0.01

Table 3
Mean coefficient of velocity of germination after fifty weeks for *Pinus radiata* seed stored at each of four temperatures and sealed in four different storage atmospheres. Each value is the mean of ten.

<table>
<thead>
<tr>
<th>Storage atmosphere</th>
<th>Storage temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Air</td>
<td>5.34</td>
</tr>
<tr>
<td>Vacuum</td>
<td>5.46</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>5.84</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>6.29</td>
</tr>
</tbody>
</table>
Table 4
Results of analysis of variance of coefficient of velocity of germination (arcsin transformed percentage of seed sown) data for the four storage atmospheres, four temperatures and eleven storage times investigated.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Mean squares</th>
<th>Variance ratio (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmosphere</td>
<td>3</td>
<td>12.64</td>
<td>151.25**</td>
</tr>
<tr>
<td>Temperature</td>
<td>3</td>
<td>23.72</td>
<td>283.70**</td>
</tr>
<tr>
<td>Time</td>
<td>5</td>
<td>40.24</td>
<td>481.19**</td>
</tr>
<tr>
<td>Atmosphere × temperature</td>
<td>9</td>
<td>0.46</td>
<td>5.50**</td>
</tr>
<tr>
<td>Atmosphere × time</td>
<td>15</td>
<td>2.19</td>
<td>26.27**</td>
</tr>
<tr>
<td>Temperature × time</td>
<td>15</td>
<td>2.37</td>
<td>28.42**</td>
</tr>
<tr>
<td>Atmosphere × temp. × time</td>
<td>45</td>
<td>0.17</td>
<td>2.04**</td>
</tr>
<tr>
<td>Residual</td>
<td>786</td>
<td>0.08</td>
<td></td>
</tr>
</tbody>
</table>

** = significant at p = 0.01

Table 5
General means for velocity of germination (arcsin transformed percentage of seed sown) data for *Pinus radiata* seed stored at each of four temperatures and sealed in four different storage atmospheres for periods up to fifty weeks. Each value is the mean of ten. Values with different superscripts are significantly different from each other, p = 0.05.

<table>
<thead>
<tr>
<th>Storage atmosphere</th>
<th>Air</th>
<th>Vacuum</th>
<th>Carbon Dioxide</th>
<th>Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.77^a</td>
<td>5.87^b</td>
<td>5.96^c</td>
<td>6.30^d</td>
</tr>
<tr>
<td>Storage temperature °C</td>
<td>5</td>
<td>15</td>
<td>25</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>6.15^a</td>
<td>6.22^b</td>
<td>6.02^c</td>
<td>5.52^d</td>
</tr>
<tr>
<td>Storage time — weeks</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>6.90^a</td>
<td>6.05^b</td>
<td>5.92^c</td>
<td>5.85^d</td>
</tr>
</tbody>
</table>

contributed to the significant interaction in the analysis noted above. The application of fungicide was later abandoned in favour of the stringent precautions outlined earlier to guard against fungal infection. For this reason it is considered reasonable not to place too much stress on the significant interaction terms in any of the variance analyses.

Originally a fifth storage treatment of 45°C was included in the experiment but all seed stored at this temperature in all storage conditions had lost viability at the end of the first five weeks. Thus, while nitrogen and carbon dioxide storage are advantageous up to quite high storage temperatures there is a limit to the possibility of maintaining viability above a temperature of somewhere between 35° and 45°C.
Table 6
Mean dry weight (mg) of seedlings of *Pinus radiata* at the end of a 49 day growth test (see text) and after storage of the seed for fifty weeks at each of four temperatures and sealed in four different atmospheres. Each value calculated from up to 20 seedlings per pot in each of ten replicate pots.

<table>
<thead>
<tr>
<th>Storage atmosphere</th>
<th>Storage temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Air</td>
<td>35.1</td>
</tr>
<tr>
<td>Vacuum</td>
<td>38.2</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>40.5</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>42.3</td>
</tr>
</tbody>
</table>

Table 7
Results of analysis of variance of mean dry weight of seedlings at the end of a 49 day growth test and after storage of the seed for fifty weeks at each of four temperatures and sealed in four different atmospheres.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Mean squares</th>
<th>Variance ratio (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmosphere</td>
<td>3</td>
<td>4.333</td>
<td>250.1**</td>
</tr>
<tr>
<td>Temperature</td>
<td>3</td>
<td>0.881</td>
<td>50.9**</td>
</tr>
<tr>
<td>Time</td>
<td>5</td>
<td>5.918</td>
<td>341.6**</td>
</tr>
<tr>
<td>Atmosphere × temperature</td>
<td>9</td>
<td>0.038</td>
<td>2.2*</td>
</tr>
<tr>
<td>Atmosphere × time</td>
<td>15</td>
<td>0.588</td>
<td>33.9**</td>
</tr>
<tr>
<td>Temperature × time</td>
<td>15</td>
<td>0.153</td>
<td>8.8**</td>
</tr>
<tr>
<td>Atmosphere × temp. × time</td>
<td>45</td>
<td>0.016</td>
<td>0.9ns</td>
</tr>
<tr>
<td>Residual</td>
<td>845</td>
<td>0.017</td>
<td></td>
</tr>
</tbody>
</table>

ns = not significant
** = significant at p, 0.01
* = significant at p, 0.05

In addition to seed viability, the rate of germination was affected by storage conditions (Table 3). The speed of germination was maintained best by storage in nitrogen, least by storage in air, it decreased faster when the seed were stored at higher temperatures and it decreased steadily with time, irrespective of the other two storage conditions (Table 4). Table 4 is derived from germination data for the whole of the fifty week experimental period and, as in Table 2, the interaction terms although significant are of little consequence compared with the main effects. Duration of storage contributes most to variance in velocity of germination, followed by temperature of storage and then storage atmosphere. A comparison of the generalised means shows the effects of atmosphere, temperature and storage time (Table 5).
Seedling vigour

Seed storage conditions markedly affected subsequent seedling growth (Tables 6 and 7). The dry weight of seedlings was highest when grown from seeds stored in nitrogen, significantly less when grown from seeds stored in carbon dioxide and, in turn, less in a vacuum, less in air. Harrison (1966) previously found lettuce seedlings grew best from seeds stored in nitrogen. Seedling vigour also declined with an increased length of time of storage (irrespective of storage treatment) and at higher storage temperatures.

In this experiment the differences in seedling vigour between different treatment groups were marked, often quite early in the test period, even though very favourable growing conditions for *P. radiata* seedlings were maintained. Heydecker (1960) pointed out that such differences could be even greater in seedlings grown under conditions of higher stress, as would apply under routine forest nursery conditions.

The results of these trials clearly demonstrate the adverse effects of the presence of air in the storage atmosphere. Oxygen not only affects viability by virtue of its presence but also due to its partial pressure (Roberts and Abdalla 1968). In the present trials the storage bag was sealed, rather than open to the atmosphere, so that partial pressure of the oxygen within the bag slowly declined. Gas analysis of the bag atmosphere revealed that the oxygen content declined from an initial 21%, to 19% at 15°C, 18% at 25°C and to 16% at 35°C. However, at 5°C the change in oxygen partial pressure was negligible. Therefore, the results obtained in these trials could be viewed as being conservative, relative to what might happen with storage of seed in an open atmosphere.

The moisture content of the *P. radiata* seed (8.05%) was within the range considered safe for storage of orthodox seeds in sealed containers (Harrington and Douglas 1970). The evidence from other experiments indicates that the effect of oxygen pressure on dry seed is not due to the stimulation of respiration but to other oxidative processes and the accumulation of subcellular damage (Roberts and Ellis 1982). Villiers and Edgcumbe (1975) suggest that subcellular damage occurs continuously in all seeds during storage at a rate dependent on moisture content and temperature and in dry orthodox seeds normal metabolic processes are so reduced that damaged cellular components are not repaired or replaced, so that damage ultimately accumulates to a level at which the seed is incapable of germinating. By contrast, for hydrated orthodox or moist recalcitrant seed the presence of oxygen is essential to sustain normal metabolism so that repair and active turnover mechanisms can minimise the adverse effects of subcellular damage (Ibrahim and Roberts 1983, Tomsett 1983).

This study showed the viability and vigour of *P. radiata* seeds can be maintained by excluding oxygen from the storage atmosphere, even at temperatures commonly expected under ambient conditions. Although these results relate directly to *P. radiata*, the storage methods should be applicable to orthodox seeds of a wide range of tree species used in plantations in the tropics and sub-tropics. In situations where refrigeration and dehumidification equipment are not available controlled atmosphere storage of seeds in laminated plastic bags, impermeable to moisture and gases, offers a simple and inexpensive means of overcoming most storage problems. The technique could also be usefully employed for the safe packing and despatch of seed to and from a central station to field stations. Seed packed in this way could withstand many of the rigours of transhipment and still be held for some time safely before being sown in the nursery.

The choice of a particular storage method will depend on the period of storage required and the costs involved. Nitrogen atmosphere storage may be optimal, but carbon dioxide is cheaper and usually more readily available, and so could be employed for most purposes, especially medium-term storage of a few months between collection and sowing in the same year. Both gases can control insect infestations in seed (Shejbal 1980, Bailey and Banks 1980), while carbon dioxide has a sterilisation effect on fungal growth and
other micro-organisms (Mitsuda and Yamamoto 1980) and while nitrogen retards fungal proliferation (De Maggio 1980). Storage of tree seed using either gas, and employing the techniques described in this paper, has considerable potential to assist in the low-cost maintenance of tree seed both in storage and during transport in a wide range of situations.

Acknowledgements

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REFERENCES


THE BRAZILIAN AMAZON REGION; FORESTRY INDUSTRY OPPORTUNITIES AND ASPIRATIONS

By J. P. CORREA DE LIMA and R. S. MERCADO*

Introduction

The utilisation of the Amazon Tropical forests is a matter of concern to many people coming from varied strata of society, from many countries. Their concerns are different, and for this reason no common policy of usage can possibly receive universal acceptance. The timber industry has a tremendous influence on the region, in terms of utilisation of the natural resource, the life style and opportunities for the people living in the region and the benefits which accrue from their operations. Equally it can be stated that it influences the nature and formation of the forest cover, the indigenous people of the region, and the ecological and environmental life style of all the inhabitants.

These notes are intended to give an impression of what is happening now and to project the hopes and aspirations of those living and working in the timber industry in this vast area of tropical forest.

The Amazon region is a huge area of almost 3.6 Mkm², 42% of the total area of Brazil. The Amazon Region is dominated by unbroken tropical forest (Figure 1).

Figure 1.
The Brazilian Amazon Region.

*Associate Professors of Forestry at the ‘Instituto de Florestas’ of the ‘Universidade Federal Rural do Rio de Janeiro’ — Address: 23.460, Seropedica, R.J. — Brazil.
Much of the region is unoccupied by people. The total population, in 1978, was 4.8M people which represents an average density of only 1.33 persons per km².

Rainfall varies from less than 1,200 mm per year to more than 4,000 mm. There is no typical dry season. However, some areas are subjected to severe dry periods of up to 4 to 5 months per year during the period October-February.

In October 1970, the Brazilian Government began construction of a number of new highways across the Amazon basin. Previous to this date, there were only two major highways in the region, BR-010 and BR-364 (Figure 2). Since 1970, additional road construction has been undertaken. As figure 2 illustrates, a network of roads is planned.

![Actual and Planned Highway Network in the Amazon Region.](image)


Figure 2. Actual and Planned Highway Network in the Amazon Region.

About 15% of the region is easily accessible by river. It is estimated that more than 8,000 km of the Amazon river and its tributaries are accessible to ocean-going vessels during most of the year. Many thousands of additional kilometers are available for smaller boats, barge or raft traffic.

### The Forest

The forest is composed of highly mixed species with a low occurrence of any specie per hectare. It has been estimated that there are probably 6,000 species growing of which only about 400 have been fully identified. Commercial usage at present is limited to about 100 species, while the number exported to world markets is less than 15.
In general we can identify the main forest types (Figure 3), namely:

**Upland Forest** — this is a forest free on higher ground which covers 90% of the Amazon. It appears to be a uniform forest, but there is much variation in species composition from area to area. This type of forest has four main subdivisions, namely:

(a) High Dense Forest — potential volume for immediate utilisation is around 60 m$^3$/ha, and shows a crowding of small and medium diameter class;

(b) High Forest of Open Structure — expected commercial availability is of the same order as in the dense forest with a higher concentration of volume in the upper diameter class;

(c) Low Forest with mergents — trees of 45 cm of DBH and more are sparse;

(d) Low Forest with vines and climbers — commercial timber per hectare is low.

**Varzea Forest** — This is a forest on periodically flooded ground. The number of months of flooding varies with the height above river level. The volume cut and logged out, on the average, ranges from 5 to 10 m$^3$/ha. Although the area of varzea forest comprises only 2.5% of the total forest area, it is responsible for more than 80% of the raw material utilized in the states of Para and Amazonas.

**Igapo Forest** — This is a forest on regularly flooded ground with stagnant water at least part of the year. The vegetation is of a special nature.

Timber volume estimates are highly speculative. The Superintendents for the Development of the Amazon (SUDAM) report estimates the total timber volume 45.7 billion m$^3$ and the volume in currently marketable species at 15.4 billion m$^3$ (Table I).

---

Table I
Timber Volume in the Amazon Region by Forest Type

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>Forest Area (Million ha)</th>
<th>Volume of All Species Per ha (m³)</th>
<th>Total (Million m³)</th>
<th>Volume in Currently Marketable Species Per ha (m³)</th>
<th>Total (Million m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upland</td>
<td>253.5</td>
<td>170</td>
<td>43.1</td>
<td>60</td>
<td>15.2</td>
</tr>
<tr>
<td>Varzea</td>
<td>6.5</td>
<td>90</td>
<td>0.6</td>
<td>30</td>
<td>0.2</td>
</tr>
<tr>
<td>Total</td>
<td>260.0</td>
<td>43.7</td>
<td></td>
<td>15.4</td>
<td></td>
</tr>
</tbody>
</table>


Based on these figures and realising the mixed composition of the forest it is not difficult to understand that after logging operations have taken place in a particular area a very substantial forest cover remains.

However, traditional logging operations as performed in most forest areas of the world are not the standard practice in the Amazon. The most heavily utilised forest land in the Amazon is concentrated in narrow strips along waterways, several hundred metres wide, with removals ranging from 5 to 10 m³/ha. Logging in the upland forest is restricted to the few areas accessible to roads. A very small proportion of the total annual extraction is carried out by mechanical operation. Even today, the timber industry is dependent for a large quantity of the raw material, from individuals using basic hand held implements to fell trees and prepare logs.

More recently the main source of supply of logs has come from areas which are being cleared for agricultural settlement programmes. These areas are usually belts on either side of new highways, which tend to give the impression of vast areas having been exploited. Certainly in the areas in close proximity to settlements, towns and cities, large areas have been felled and cleared. To put this in the right perspective it should be understood that this process has been carried out over hundreds of years, yet the cleared area taken as a portion of the whole Amazon Forest would not amount to 5% of the total.

With the pressures of increased population, and the needs of the people of the region, this process has accelerated over the last ten years. The introduction of the satellite LANDSAT Monitoring Programme has effectively enabled the areas being utilised to be calculated on an annual basis. Interpretation of this data has shown an increase in the annual denudation over the past few years, in the Amazonian areas, but has also shown substantial reforestation at the rate of 500,000 hectares per year in other parts of the country. The reforestation programme is one of the most impressive programmes in the world.

No current review of the Amazon region would be complete without comment on the successful experiment carried out in the Jari Project. In all aspects but one, this venture has been a success. Ludwig has proved that after utilising the existing natural forest the introduction of selected exotic species can perpetuate a forest which can be economically utilised to provide an industry based on timber and timber derivatives. The only aspect of failure can be attributed to a human factor; that of the egotist failing to account for and appreciate the aspirations, feelings and needs of the people and the country in which he was conducting his operation.
At present a substantial programme has commenced near Santarem (State of Para) with a pilot project implementing a managed utilisation of 600,000 hectares of Tropical Forest. This project being carried out by FAO and Brazilian Institute for Forestry Development (IBDF) demonstrates how by selective logging, backed by research and detailed inventory record, natural regeneration, augmented where necessary by enrichment procedures, will permit utilisation on a sustained basis.

With the development of an experience in these practices, utilisation of further areas of the Amazonian forest will only be permitted using the regimes devised under this pilot project.

The Timber Industry
In 1952 there were 100 sawmills operating in the greater Amazonian region; in 30 years, i.e. by 1982 this number had risen to 1,650. Many of these have a low annual production when it is realised that of the estimated total annual production of sawn timber 5.4 million m³, 92% of the sawmills produce just 70% of the production. Larger mills classified as those with a production in excess of 10,000 m³ per annum represent just 8% of the total, but produce 30% of the volume (Table II).

<table>
<thead>
<tr>
<th>Annual Production (m³)</th>
<th>Number of Mills</th>
<th>%</th>
<th>Lumber Output (1,000 m³)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 5,000</td>
<td>1,050</td>
<td>64</td>
<td>1,544</td>
<td>29</td>
</tr>
<tr>
<td>5,001-10,000</td>
<td>459</td>
<td>28</td>
<td>2,267</td>
<td>42</td>
</tr>
<tr>
<td>over 10,000</td>
<td>131</td>
<td>8</td>
<td>1,582</td>
<td>29</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,640</td>
<td>100</td>
<td>5,393</td>
<td>100</td>
</tr>
</tbody>
</table>


To improve the standard and quality of the production, ‘Grading Rules for Brazilian Tropical Sawn Hardwoods’ were formulated and introduced in September 1983. These rules based on the work of ATIBT (Association Technique International des Bois Tropicaux) and CTFT (Centre Tecnique Forestier Tropical) provide a system of grading suitable for the highly mixed species available and acceptable to the requirements of the international market.

With the objective of increasing the volume of exports and improving the reliability of shipments, a system of warehouses will be established in key areas of the Amazonian region. The first of them located at Santarem (State of Para) on the Tapajos river has been operating since late 1982. Basically they will be co-operative collecting centres where sawn timber can be accumulated, graded and packaged. The objective being to encourage the smaller sawmillers to participate in the exporting of timber and also to increase the volume by promotion of suitable hitherto unknown species.

Monitoring of the requirements and output of these mills will assist in identifying areas which will benefit from technical assistance. Subjects will include saw and machine
maintenance, cutting techniques, quality control, handling, log storage, grading and treatment to prevent timber degrade.

Appropriate action would then lead to a better and more consistent product and a much higher utilisation and recovery from the existing resource.

The Expectation

In many areas of the Amazon, research and experimental work is being carried out in reforestation with both indigenous and exotic species. A private experiment in the west of Mato Grosso has shown with plantations of teak after 12 years, remarkable annual growth increments. As the results conducted on thinnings show high quality timber the annual planting area has been considerably extended. Government research centres in Manaus (capital of the State of Amazonas), Santarem (State of Para) and Belem (capital of the State of Para) are now beginning to assess the results being obtained from regeneration and reforestation of indigenous specie experiments. These are just some of the programmes being conducted. Results are giving a wider and better understanding of the requirements and conditions which will increase, sustain and perpetuate this vast forest area.

The expectations of all these ventures are to provide greater employment opportunities for those living in the Amazonian region and improve their life style and living standards. From a National viewpoint the utilisation of a larger number of species and increased exportation will realise a substantial return from a natural resource which hitherto has contributed little to the economy.

With this utilisation, based on the regimes devised in the Tapajos National Forest, a sustained and perpetual harvest will assure the inhabitants of the area a continuity of employment opportunities and the enjoyment of higher living standards.

The experience gained from the Jari project will contribute greatly to the development programme of reforestation both with indigenous and exotic species.

This controlled and managed concept of tropical forest utilisation enhanced by enrichment programmes of indigenous species and reforestation with exotic species in areas where national regeneration is not practical or possible will effectively ensure a continuous forest cover.

The Amazon region is unlikely to be fully tamed, but it can and is contributing to a better life for the present and future generations of its inhabitants.
Requests for any publications reviewed or noted below should be addressed to the appropriate publishers and not to the Association.


The description on the dust jacket states that this book, by the novelist Thomas Hinde, ‘takes the major forests of Britain, both ancient and modern and relates them as they exist today to their history. It describes . . . controversies between the King, the commoners and the landowners . . . It looks at the industries of the forests and questions two common assumptions; that charcoal for iron-making and timber for ship-building destroyed our forests’.

The book attempts to combine historical evidence with ecology and forestry practices in a popular and often anecdotal way. The result is regrettably superficial and the text displays so many minor errors of emphasis or fact on the ecological and forestry side that most foresters, at least, would lose confidence in the accuracy of the historical accounts as well. Unfortunately, very few sources of information are quoted and there are no references. The sort of errors noted include (p. 38) ‘there are between 50 and 70 native British trees’. Even if the definition of a tree is stretched to its limit, there can be no more than about 35. On p. 127 there is a most dubious generalisation about Dartmoor’s plantations which are described as ‘the most productive in the country’, and on p. 253 and 280 the quaint but possibly intelligible new term ‘bashing up’ is used for replacing dead plants. The questioning of the assumption that charcoal-making and ship-building destroyed Britain’s forests has been done much more authoritatively by Oliver Rackman in 1976 in his Trees and Woodland in the British Landscape, and though Rackman’s work is referred to in several places in the book, it is not in this context.

The book is written sympathetically towards forestry, even present-day coniferous forestry, but the treatment given to the different forests in Britain varies widely. Anything north of the midlands of England gets scanty attention. The book contains numerous attractive illustrations, some from John Evelyn’s Sylva and other historical works. Unfortunately many of them have no captions at all, and for the source of each, one has to refer to the last page of the book. A regrettable omission is of a map showing where the forests are located.

This book may have a value for a layman with a casual interest in forestry but for a serious student of either the science of forestry or of its history there are many more authoritative works.

P. S. Savill


The worldwide panacea seen by the authors for satisfying mankind’s needs for food, fuel and other essentials is ‘forest farming’. Forest farms consist of large belts or blocks of economic trees interspersed with narrower strips of grasses along which herds of livestock move, fed from the woodlands. The system, they say, forms a natural biological cycle into which man fits perfectly. The trees provide food, fuel and other essentials and, at the same time conserve the land against erosion. The animals provide meat, milk, eggs and wool, and manure the soil. Such farming is seen as providing a rewarding and purposeful way of life for large numbers of people.

The authors apparently advocate the transfer of what may often be highly complex expensive systems into foreign cultures. They scarcely recognise the scientific, technical, economic and political problems of doing so or the fact that traditional farming systems have usually evolved in some sort of harmony with their environments and may have some merits. Many are no longer successful because of climatic fluctuations and recent enormous rates of population growth in the regions where shortages are most severe. There is a total failure to appreciate that each part of the world has its own special problems that require their own solutions. One cannot simply transfer techniques from one place to another with any expectation of success. There is scarcely a mention of the recent advances and detailed research being carried out on the potential of woody species in agriculture by such organisations as the International Council for Research in Agroforestry in the tropics, or by many temperate countries concerned with short rotation ‘energy’ plantations.
The book is pervaded by naivety and grossly misleading statements. For example, trees are seen as plants which maintain water tables near the surface 'by the suction effect of the forest's multitudinous root-system'. Without trees, water tables 'sink deep into the subsoil, and the flow of springs and wells diminishes until they completely dry up'. The authors fail to emphasise that much of the world is too dry, too wet, too hot, too rocky or too salty to permit high levels of production without enormous investment. Examples of production quoted (e.g. p. 5) are therefore grossly inflated for the average conditions suggested by the authors (though some exaggeration is implied in an obscure addendum on p. 204).

In the chapter in 'Fields for expansion: temperate uplands', there appears to be an implication (p. 148) that the British uplands could be planted with sweet chestnut, almond and walnut trees, among others. These species seed only moderately well only in the most favoured lowland conditions and scarcely at all in the uplands where they would be most unlikely to survive. Japanese larch is described as 'one of the fastest growing trees in existence' (p. 145). Britain must indeed be lucky since it has at least half a dozen others which will grow almost twice as fast as larch. There is also a failure to recognise that few temperate countries need trees to supply fodder. Why should they rely on leaf fodder or meal made from fruits when grass grows so well? It is in countries with seasonally dry climates that trees can play such an important role in this respect.

A surprising omission from the book is any mention of the potential food which can be supplied from the mycorrhizal associates of trees or from saprophytic fungi on dead wood.

No experienced forester, agriculturalist or biologist would give this book a second glance. However, if read by the inexperienced and impressionable student, it could have a dangerously misleading influence.

P. S. Savill


The author sets out to compile a text book on tropical silviculture based upon over 300 articles published during the last 40 years. He draws upon his ten years of teaching experience in Nigeria and his visits, aided by a FAG Fellowship, to other African countries, to the Far East and tropical Australia.

At the time of the work's conception, a trainee silviculturalist in the tropics would have had little access to many of the papers selected for their contribution. Subsequently, authors such as T. C. Whitmore published 'Tropical Rain Forests of the Far East', and D. J. Evans, 'Plantation Forestry in the Tropics'. Mr Nwoboshi makes the point that as soon as forest management is achieving acceptable levels of economic species stocking, the damage during felling and extraction is such that it is appropriate to clear fell and create a plantation. Two of the four sections in the book concentrate upon Nursery Technology and Plantation Technology, part of one of the other sections also discusses forest regeneration. It is not until a third of the way through the book that Tropical Forest Formations, their distribution and silviculture brings the student in close contact with the subject of the book's title. Pages of detailed information on photosynthesis and respiration would have been better omitted or a paragraph on each would have been adequate for the individual who intends to establish, manage and utilise forest resources. They are unlikely to benefit by learning that 'the mitochondria are also the centres of synthesis of the ATP (Adenosine triphosphate) associated with respiration'. A second edition of the book, which is well worth while, could include a glossary or vocabulary as a student might well wish to look up such common terms as 'wolf', 'damping off' and 'epicormic'.

The author hopes that the book will attract readers in countries outside Nigeria but the locations cited as examples need locating on maps with some indication of latitude, altitude and rainfall distribution. Prices in 'Naira' might be better represented as multiples of daily pay. The student would appreciate charts showing various soils and rainfall distributions with appropriate species for various end uses. Although utilisation has a passing mention it deserves greater emphasis as it should influence forest management. The reviewer does not agree that (p. 121) 'A good silvicultural system should therefore prevent drift in forest management which may be caused by fluctuations
in market demands . . . ', neither with (p. 295) 'knot size — not particularly important in structural
timber'. There are a few errors of fact which require attention: (p. 74) *Dothistroma pini* (which
is a needle blight of pines) is suggested as a root rot, (p. 67) 'rainfall dissolves nitrogen', (p. 61)
'chlorine supplied through the atmosphere', in Fig 15.3 the removal of 75 trees from 170 apparently
leaves 100, in Fig. 15.2 an atypical bump on the curve suggests that instant mature trees arrive
in the forest. It is not clear why in Fig. 15.3 the removal of every third row should produce a dramatic
increase in residual diameter size class.

The printing and presentation of the book is to be applauded, apart from the arbitrary hyphenating
of words at the end of a line which irritates with examples such as 'ot-her', 'ho-wever', 'mo-or',
'po-orly', 'su-gar' and 'so-luble'. A few spelling mistakes — *Pin ius, Sterenum*, damage, floatation
and another dozen require editing; the actual sense is lost on p. 220 where 'to minimize soil
improvement' should read as 'soil impoverishment' and p. 143 where m$^2$ should be m$^3$. A phrase
is duplicated on p. 129 and a line duplicated on p. 135. *Bacteria nigritiana* should be *Barteria nigritiana*
and it appears as such in the index. The 'unknown mechanism by which this species kills its
competitors' would soon become apparent on contact as it is usually inhabited by a vicious ant
which repels boarders and chews through adjacent vegetation. The general index is very good with
776 items having over 2,000 mentions in the text. The references are tabulated in alphabetical order
with alphabetical author references to the text (two lists).

The author is to be congratulated on having the initiative, dedication and perseverance to collate
such a wealth of information and it is hoped that he will still have sufficient reserves of energy
to implement the suggested minor alterations so that the second edition can become a standard
text book.

M. T. Rogers

Global Deforestation and the Nineteenth-Century World Economy. Edited by Richard P. Tucker
Price $35.75.

*Global Deforestation* is not an easy book to read. With yellow-tinged paper, narrow margins, a
 cramped print and a strictly utilitarian layout, an absence of illustrations and, surprisingly in a
book that describes the landuse history of a range of countries, maps, it reminds me of books
published in wartime Britain. Presumably this is a commentary on the economics of book publication
at this time but I wonder how many readers can place Thayatmyo, Pyapom, the Siwaliks, Northern
Bulacan, Nueva Ecija, Raver or even the Karmatak without recourse to a map?

The book comprises a number of papers loosely joined together by a common theme of
deforestation during the one hundred years prior to the First World War, presented during a meeting
held at Oakland University in 1981.

In these essays, the authors set out to show that this global trend to deforestation was not so
much a response to pressure of growing population as a function of world market forces generated
by Europe's growing demand for commodities and raw materials; that there was a link between
accelerating worldwide market demand for foodstuffs, fibres, and raw materials, the clearing of
land for expanding cash crop production, and accelerating destruction of forest cover.

As a forester this reviewer found wry amusement in the postulate that the impetus for forest
clearing came from 'outside forest management', for by definition forest management is concerned
with the management and sustentation of woodlands rather than their destruction. Indeed it was
in response to the forces of forest destruction, some of which are described in these papers, that
the profession of forestry came into being. Seemingly there is some confusion here between logging
and forestry.

Almost certainly the editors overstate their case when they suggest that these case studies for
the first time reveal the full extent of this process of economic and environmental change, a process
that they claim has been obscured in the past by compartmentalisation of national histories and
the lack of integration between economic history and forest history. However there can be full
agreement with their perception of the need to bridge the abyss between the social and historical
sciences on one side and the ecological sciences on the other and of the desirability of an
interdisciplinary group approach. It is a pity therefore that although the meeting at which these
papers were presented was also attended by discussants from forestry, forest economics and anthropology, with one exception all the papers presented in this book were by American scholars and predominantly by historians. A stronger international and interdisciplinary mix and the inclusion of contributions from the land use disciplines — forestry, agriculture, regional planning — would have been desirable.

There is no question but that the century preceding the First World War saw an integration of the world's economy, though 'unprecedented' is perhaps too strong a word to use when one recalls the Imperial System of classical Rome. The imposition of indirect or direct political and economic control by the industrialised nation states of western Europe and North America was well under way by mid-century and there is no question that sharply enhanced demand for commodities in the metropolitan countries were transmitted outward to much, if not the remainder of the globe as is suggested by the editors. Increased production was obtained by increasing the area under cultivation rather than by more intensive labour or more intensive land use technology. The result was the steady destruction of the world's woodlands and forests especially in the regions which were being newly integrated into the world economy. The editors claim that the rapid expansion of monocrop commodity production was one of the primary reasons for today's dangerous imbalance between 'First World' and 'Third World', in that while the process probably brought increased real income to third world societies, after 1920 the terms of production and trade became unfavourable, and opportunities for bringing new lands under cultivation became increasingly limited. They trace present patterns of rapidly rising population and local needs for food production on depleted soils, to a rapid acceleration of the process from the end of the First World War.

While in general the papers presented support these hypotheses there is possibly a certain selectivity. The classic example of forest and resource destruction is the Mediterranean basin. Here the processes involved do not support the hypothesis of rapid exploitation by imperial or advanced powers, but rather a steady wearing out or attrition consequent on the interaction of environment and cultural forces and intensified by population increase, which resulted not from the market forces of imperialism but consequent on greater political stability, greater security and improved public health during the last 150 years largely due to the intervention of the advanced nations.

Nevertheless the individual papers provide valuable descriptions of resource development and changes in land use in the countries that they address. Williams, an Oxford geographer, describes the agricultural clearance of the oak-hickory forests of Ohio; Cox, a historian from San Diego, surveys the timber operations in Oregon and Washington to 1920; Roth, a historian with the U.S. Forest Service, shows the impact of the transition of the Philippines from Spanish to American control at the turn of the 19th century; Dean, a historian from New York University, discusses the clearances in southeastern Brazil in the turbulent aftermath of Portuguese rule which resulted in the replacement of 500,000 square kilometers of rain forest as far south as Sao Paulo state by sugar cane and coffee plantations. Richards' (History, Duke) and McAlpin's (Economics, Tufts) topic is the expansion of agriculture in the Bombay Deccan, while Adas, a historian from Rutgers, describes the movement of the peasantry of upper Burma into the lower Irrawaddy Delta to clear new rice lands after the British conquests. Deforestation in China during the era of western imperialism, after severe degradation by many centuries of prior human pressure, is surveyed by Murphey, a Michigan geographer. From the University of Illinois Osako describes Japanese forest management during the Tokugawa era of the 17th to mid-19th centuries, giving us one of the few glimpses of the long and indigenous forestry tradition of the Japanese islands, which evolved under very different conditions from those that produced professional forestry in Europe. Tucker, historian from Oakland, describes the evolution of forest management by the Indian Forest Service, which he correctly identifies as the non-European world's first and most sophisticated forest service, in the western Himalayas, while Thomson describes the open woodlands in the Sahelian savannah before French colonial rule took hold.

In total these papers are valuable individual contributions to our knowledge of tropical forest use in the countries discussed, while the Preface develops the theme on the world stage. Together they set the stage for an intended second conference which will focus on the exploitation (which I trust will be defined in the forestry sense of the word as well as the more emotive connotation of ruthless, unthinking destruction) of the tropical forest from the First World War onward. This, to the post-Second World War Period of rapid decolonialism, was the time of considerable advance in the development of tropical forestry by the forest services of the imperial powers, whether these
are seen as trustees, stewards, tutors, despoilers, or all four, depending upon one's political proclivities.

It is presumed that the papers now published were discussed at the meeting at which they were presented. It is a pity that an account of these interdisciplinary discussions was not included in the book. Perhaps the editors will consider this for the next meeting of the series.

J. V. Thirgood
Professor of Forestry
University of British Columbia


This book is a valuable contribution to the source literature on forestry development. It represents the proceedings of an international symposium 'Let there be forest' in 1983 to mark 100 years of forestry education and research in the Netherlands. The organising committee is to be congratulated on the content of the symposium and for arranging for experienced, generally well known speakers/authors who presented information and ideas highly relevant to the theme. The editor and publishers deserve praise for the high standard of editing with few minor typographical errors and for the uniform style and good quality of printing and binding. Although some of the information included in the paper has appeared elsewhere, it is in scattered journals, bulletins and agency reports, not always easily accessible; this book provides an excellent compendium.

The long and complicated title could be replaced by 'Planning forestation' (as defined in the introduction) for this is what the symposium considered. The committee wished to examine advantages and constraints of different forestation systems (afforestation, reforestation and tree planting) to provide a nucleus of information and ideas on successful strategies and designs for creating new forests and tree resources. The committee recognised the need for strategic, tactical and operational planning and invited papers on each of these, together with case studies and papers describing basic planning techniques. Virtually all of the papers are relevant, although their grouping in the sessions and proceedings does not appear totally logical.

Setting the scene on the aims and objectives of forestation in development were three papers by well known international foresters. J. S. Spears (World Bank) reviewed the role of forestation as a sustainable land use supplying wood needs in developing countries; J. E. M. Arnold (FAO) considered the aims and constraints of forestation for local community development; T. J. Peck (FAO/ECE) examined trends in consumption of forest products and their implications for forest plantation policies. These were supported by reviews of the effects of forestation on soil and water management (J. Evans) and biological diversity (G. Budowski), and by some seven case studies ranging from biomass energy in Bangladesh to lessons learned from early plantings in the Sahel.

The section on diagnostic methodologies for forestation included papers on land evaluation (H. F. Gelens), a review of all project diagnostic techniques (some of which will be unfamiliar to many foresters) by L. Pancel and C. Wiebecke, use of Landsat imagery (J. Gonzalez Durazo) and the ICRAF diagnosis and design methodology for agroforestry by J. B. Raintree.

Specific analyses of forestation design components were concerned largely with silviculture and management failures (J. K. Jackson), economic assessment of industrial plantations (R. A. Sedjo), comparison of incentives (H. R. Gregerson), institutional arrangements (D. J. Palin), training and extension for community forestry (E. D. Pelinck et al.) and ecological stability (E. F. Brunig).

The final section considered all stages of planning and implementation of forest development in Java (Hartono et al.), the place of non-Governmental organisations (A. Grainger), and the evolution of the present international forest policy and activities of development agencies, leading to a description of international and national action required on forestation (R. Levingston, FAO); these latter two papers included valuable lists of non-Governmental organisations and national programmes of international cooperation in forestry.

Following discussions of the presented papers and consideration of the 68 posters, the symposium issued a final document including many recommendations on increasing planting within and outside
the forest, increasing donor assistance, and increasing public awareness, all within the context of appropriate, systematic planning and policies. The title of the symposium was ‘Let there be forest’; let there also be policy makers, administrators and technicians with the time and wisdom to read and apply the lessons imparted in the symposium proceedings.

Dr J. Burley

REVIEW NOTES


In 1979 the ASEAN South East Asia Regional Centre for Tropical Biology, BIOTROP, at Bogor, Indonesia, ran a training course on the autecology of forest plants. Dr Ng from Kepong gave six lectures on phenology which were published by BIOTROP but without illustration. They are reprinted here in a more accessible form, together with numerous line drawings and photographs.

These lectures form an admirably clear and concise account of the complex subject of the phenology of tropical trees. Shoot growth rhythms are described, leading naturally into an analysis of leaf life and exchange which itself involves analysis of the deciduous habit, seen to be a limiting case. Then the even more important subject of flowering and fruiting and their periodicity is analysed which concludes with an account of the state of knowledge of the sporadic mass flowering exhibited by Dipterocarpaceae, not only fundamental constraint on dipterocarp rain forest silviculture but also of considerable scientific interest.

This Research Pamphlet should be on the shelves of everyone concerned with the phenology of tropical plants.

Dr T. C. Whitmore


This is a useful and well illustrated publication describing the construction and operation of a new design of brick-built charcoal kiln designed by the authors and successfully tried in a number of tropical countries.

It has a greater capacity than the TDRI all-metal kilns but is less mobile and is, therefore, particularly suitable for sites where there is a long-term supply of wood such as a sawmill producing a regular supply of wood residues.

No single design of charcoal kiln is likely to suit all conditions and TDRI now have three designs of kiln to suit different circumstances — the circular metal kilns, this kiln and the modified pit kiln.

Low initial cost, a minimum of imported materials, ease of operation, efficient operation and long life are desirable aims for charcoal kilns in the tropics. This kiln has achieved in large part most of these requirements. It would be desirable to be able to do without the concrete foundations in countries where cement is not manufactured and 3 mm sheet metal may be expensive and difficult to get, but a trade-off has to be made between efficiency, productivity and the cost of imported materials. This is why different kilns designs suit different conditions.

There is no doubt at all that charcoal is becoming a very important product in much of the tropical world and its efficient production and use are vital to efficient use of often very limited forest resources.

This is, therefore, a publication which should prove a practical and useful tool in improving wood use in many tropical countries.

R. A. Plumptre
Progress on the Vegetative Propagation of Agathis: A report by T. C. Whitmore, A. Garton and J. Steel. Commonwealth Forestry Institute, Oxford University.

*Agathis*, a genus of 13 species of conifers (family Araucariaceae), mainly found in the Eastern tropical rain forests, has great potential as a plantation tree where high value timber is required. A detailed study has been made and a limited international trial set up of 9 provenances at 23 locations by the CFI (Whitmore 1977, Bowen and Whitmore 1980a,b). Hilleshög of Sweden are currently developing further the work begun at Oxford. Seed of any given provenance is always likely to be in limited supply. Here we report work on vegetative propagation and show that this is now a realistic possibility for multiplication.

Cuttings from *Agathis* seedlings were first successfully rooted by A. K. Longman at Edinburgh. It was found that main stem cuttings rooted better than cuttings of lateral shoots, and the younger the stock the greater the success. Rooted cuttings were successfully introduced to Peninsular Malaysia and were doing well after two years. These studies have been reported by Whitmore (1977) and Bowen and Whitmore (1980a). The work has since been extended using a mist propagator with bed temperature 25°C at Wytham near Oxford.

In Peninsular Malaysia the plagiotropic seedlings never became orthotropic. This suggests that it is necessary always to strike cuttings from orthotropic shoots if, as is usually likely to be the case, vertical trees are wanted. In this trial, all the *Agathis robusta* died at c. 3 years from planting, perhaps after a spell of dry weather. This is a subtropical species and in Malaysia was growing well outside its normal climate. Records of scattered trials throughout the tropics show *A. robusta* to have grown faster than others (Whitmore 1977). These trials were almost certainly on trees grown from seed.

We have conducted two experiments. The first one, on *A. macophylla Fiji Provenance* (formerly *A. vitiensis*) also showed rooted plagiotropic cuttings did not become orthotropic with age. This experiment also showed that:

1. when a seedling is decapitated bigger shoots are produced by cutting at a top node than a lower one;
2. bigger shoots root better than small ones and can form roots in 2 months; but
3. very big cuttings have a tendency to rot below soil level. It was also found that good rooting resulted from dipping cuttings in *Seradix* brand rooting hormone (grade 2, pink, for softwood cuttings) and planting in the mist propagator into an equal mixture of ‘Perlite’ brand polystyrene granules and coarse sand. Calloses develop and then roots. Most cuttings had developed roots by 4 months, the remaining cuttings rooted over the next few months. Once rooted, the cuttings were potted on and grew slowly. After a year, there had been very few deaths.

The second and main experiment used the same techniques. It was aimed to discover how many orthotropic cuttings can be obtained from a single stock plant. Seedlings growing in 6 inch pots, c. 45 cm tall and grown in a humid tropical glasshouse were used. They were decapitated to an upper node which stimulates the growth, from dormant buds near the apex, of several orthotropic shoots. These were themselves cut off and rooted. The stock plants produced more orthotropic shoots which were cut off. In total 5 decapitations were made. The first four decapitations were followed by the growth of new shoots on the stock plants.

The interval between successive decapitations needs to be c. 4 months to permit new shoots 4–5 cm tall to grow. The first three decapitations were followed by the growth every time of about the same numbers of new shoots, there were fewer of the fourth generation and none, by 4 months, of the fifth generation.

Results differed slightly between the species tested. *A. macophylla Aneityum (Vanuatu) Provenance* (formerly *A. obtusa*) stock was 48 months old at the outset. It produced c. 7, 5, 6 and 3 shoots in successive generations. For silviculture, this is potentially the best taxon and it is therefore good that it did well. About equal was *A. macophylla Ndendo Provenance* with c. 4, 4, 7 and 6 shoots from stock seedlings of 38 months age initially. Third best was *A. moorei* (49 months old stock) with 3, 3, 2 and 4 shoots. Finally *A. robusta* spp. *nesophila* (stock 38 months old) seedlings died at the first decapitation.
We conclude that, even with stock seedlings several years old at the outset and in the conditions of a north temperate glasshouse, useful numbers of cuttings can be made for several generations of 3 out of the 4 taxa tested, and several generations a year are possible.

Finally, we draw attention to experiments in Holland on vegetative propagation of *A. dammara* Javan provenance by Smits (1983) who successfully rooted very small leaf cuttings made from 7 month old, 30 cm tall seedlings. Like us he found plagiotropic shoots produced plagiotropic cuttings. They developed a ‘Pen’ (i.e. tap) root, unlike his and our stem cuttings. He claims trees grown from these would be less likely to be blown over by a high wind. No one has yet demonstrated though whether the spreading lateral roots of *Agathis* develop vertical ‘sinker’ roots, as was shown recently to be found in many species in a Sarawak rain forest (Baillie and Manit 1983).

REFERENCES


A note on Early Observations of *Leucaena leucocephala*: (N. LACKHAN; Director, Northern Range Reafforestation Project, Trinidad and Tobago).

The Northern Range Reafforestation Project, in a continuing programme of evaluating species for watershed rehabilitation, received a small quantity of seeds of the K8 variety (Hawaiian Giant) of *Leucaena leucocephala* from the Department of Horticulture of the University of Hawaii. This request was made because the literature indicates that excellent results are being obtained in countries where watershed rehabilitation is being undertaken with this species.
Nursery Work
(a) **Pre-treatment of Seeds.** On account of the thickness of the seed coat, two treatments were undertaken:

(i) Immersion of seeds in concentrated sulphuric acid for ten minutes and subsequently washing them thoroughly with running water for thirty minutes. The seeds were then placed in a wet jute bag for two and a half days.

(ii) Scarification with a file and keeping them moist in a wet jute bag for two and a half days. Better germination (approx. 60 per cent) was obtained with the first method. It is interesting to note that seeds later collected from the trees germinated easily. This is very similar to teak seeds collected from local sources which are said to be difficult to germinate in some countries.

(b) **Growth Medium.** In order to determine the best growth medium for the seedlings, the seeds were sown in varying mixtures of forest top soil, pen manure, bagasse and sand. The most suitable soil medium found was a 2:1:1 mixture of forest top soil, pen manure and sand.

Field Trials

(a) **1980 Experiments.** In 1980, two plots were established at Mt. St. Benedict (elevation 200 m) and St. Michael (elevation 150 m). The soil in each site is of the Maracas/Matelot soil series, with free internal drainage while the topography is very steep.

Unfortunately, most of the seedlings of the St. Michael site were cut down by squatters but have shown excellent coppicing properties. The average height of the trees at Mt. St. Benedict is 10 metres and the average girth at breast height (gbh) is 20 cms.

At both sites, trees and coppice shoots, flower, fruit and produce viable seeds. Natural regeneration is abundant.

(b) **1981 Experiments.** In 1981, two seedlings were planted in the St. Joseph Nursery Compound where there is a deep loamy soil. The site is flat and well-drained. To date, the trees have attained a height of 13 m and 11 m and gbh of 56 cms and 53 cms respectively.

At the Carenage plantation (elevation 160 m) a small plot of the species was planted at a spacing of 1 m x 1 m to determine its use as a fire break. Unfortunately the plot was destroyed by squatters.

(c) **1982 Experiment.** A replicated species trial using three fast-growing exotic leguminous species (*Leucaena leucocephala, Sesbania grandiflora* and *Albizia falcataria*) was established in 1982 at St. Michael. Espacement used was 3 m x 3 m.

Measurements of heights and diameter at breast height (dbh) after two years are as follows:

<table>
<thead>
<tr>
<th>Species</th>
<th>Height (cm)</th>
<th>dbh (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Leucaena leucocephala</em></td>
<td>202</td>
<td>1.54</td>
</tr>
<tr>
<td><em>Albizia falcataria</em></td>
<td>339</td>
<td>3.74</td>
</tr>
<tr>
<td><em>Sesbania grandiflora</em></td>
<td>317</td>
<td>3.30</td>
</tr>
</tbody>
</table>

Conclusions

Observations made to date indicate that the K8 variety of *Leucaena leucocephala* can be successfully used in watershed rehabilitation. Its fast growth, good coppicing power, ability to enrich the soil and prolific natural regeneration are excellent qualities for this type of work.

A major disadvantage of the species, however, is that it grows poorly in sites with a pH lower than 5.5 and such areas may be prevalent in the Northern Range. The trials with other leguminous species, however, already indicate the *Sesbania grandiflora* and *Albizia falcataria* may also be used as alternative species.

REFERENCE


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Nursery Diseases of Broad-Leaved Trees (M. JALALUDDIN, * University of Karachi.)

The tribal inhabitants of Chittagong Hill Tracts, Bangladesh, have indiscriminately felled trees in the last two decades. The gaps so created in the forests were prepared for reforestation. An observation on the germination and growth of 10 species of broad-leaved tree seedlings in nurseries showed approximately 80% pre-emergent and post-emergent death. Representative samples of diseased seedling roots were collected from nursery beds, surface sterilized with 0.1% Na-hypochlorite and transferred on PDA medium containing 0.1% streptomycin sulphate. The fungal colonies arising from these roots were studied and identified.

*[Formerly at the Department of Botany, University of Dacca, Bangladesh.]*
A total of 12 species of fungi were isolated from the roots of diseased seedlings of 10 tree species (Table 1). The description, distribution, locality factors and floristics of Chittagong Hill Tracts have been described by Champion, Seth and Khattak (1960–65). Not all of the isolates have been previously reported either as seed or root parasites of forest trees, but the two species of *Fusarium* encountered most frequently during the course of this work are well known agents of root rot diseases (Booth, 1971). In the neighbouring country, India, *Rhizoctonia solani* is an important cause of ‘damping-off’ in forest nurseries (Reddy, 1969).

Two species of *Trichoderma* isolated from the root samples in the nursery may be considered significant, for these are usually obtained from a soil suppressive to soil-borne pathogenic fungi and have the ability to protect seeds from them (Hardar, Harman and Taylor, 1948).

A number of *Pestalotiopsis* spp. have been reported on various gymnosperms (Noble and Richardson, 1968) and here a species of *Pestalotiopsis* is reported as being parasitic on *Anisopetra glabra* Kurz, an angiospermous plant.

I wish to thank the Director, Commonwealth Mycological Institute, Kew for getting the fungal isolates verified by the staff of the Institute.

### Table 1

**Fungal Organisms Associated with the Roots of Diseased Seedlings of Broad-Leaved Tree Species**

<table>
<thead>
<tr>
<th>Names of the Tree Species</th>
<th>Names of Fungi</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Swintonia floribunda</em> Griff.</td>
<td><em>Cochliobolus specifer</em> Nelson (IMI 152914)</td>
</tr>
<tr>
<td><em>Cassia nodosa</em> Buch (Ham ex Roxb.)</td>
<td><em>Fusarium solani</em> Mart. &amp; Sacc. (IMI 152914a)</td>
</tr>
<tr>
<td><em>Terminalia chebula</em> Retz.</td>
<td><em>Aspergillus quadricinatus</em> Yuill (152919)</td>
</tr>
<tr>
<td><em>Holigaran</em>a <em>longifolia</em> Rox.</td>
<td><em>Trichoderma aureoviride</em> Rifai (IMI 152916)</td>
</tr>
<tr>
<td><em>Podocarpus nerifolia</em> D. Don.</td>
<td><em>Fusarium oxysporium</em> Schlecht (152921)</td>
</tr>
<tr>
<td><em>Amoora wallichi</em> Wright.</td>
<td><em>Penicillium spiculispersorum</em> Lehman (152925)</td>
</tr>
<tr>
<td><em>Michaelia champaca</em> Linn.</td>
<td><em>Trichoderma koningii</em> Oud. (IMI 152922)</td>
</tr>
<tr>
<td><em>Syzygium grande</em> Wall.</td>
<td><em>Fusarium solani</em> Mart. (Sacc) (152933)</td>
</tr>
<tr>
<td><em>Anisoptera glabra</em> Kurz.</td>
<td><em>Fusarium oxysporum</em> Schlecht (152926)</td>
</tr>
<tr>
<td></td>
<td><em>Aspergillus chevalieri</em> Thom &amp; Church (152938)</td>
</tr>
<tr>
<td></td>
<td><em>Penicillium funiculosum</em> Thom (152931)</td>
</tr>
<tr>
<td></td>
<td><em>Fusarium oxysporum</em> Schlecht (152932)</td>
</tr>
<tr>
<td></td>
<td><em>Collectotrichum</em> state of <em>Glomerella cingulata</em> (Stonem) spauld. and Schrenk (152936)</td>
</tr>
<tr>
<td></td>
<td><em>Fusarium solani</em> Mart. (Sacc) (152940)</td>
</tr>
<tr>
<td></td>
<td><em>Pestalotiopsis clavispora</em> Atk. (Stayaert) (152937)</td>
</tr>
</tbody>
</table>

Note: The alphabetical and numerical numbers in parentheses are the accession numbers of the herbarium at CMI, Kew, England.

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EDITORIAL

Conference Time

This issue of the Review attempts to cater for those fortunate enough to be able to attend the 12th Commonwealth Forestry Conference and for the other members in their respective 76 countries. The 1st Empire Forestry Conference was held in 1920. One of its recommendations was that a ‘Forestry Society’ be set up to keep foresters in touch with each other between conferences; it also recognised that an international organisation could play a part in ensuring a continuity of supply of timber as a raw material for industry. It was appreciated that there was a need to collect and disseminate forest information, to initiate research and to report conclusions, to educate the public into the significance of trees so that their benefits might be acknowledged, developed and funded.

Foresters tend to supervise large tracts of land which implies a degree of isolation, requiring the ability to make rational decisions and to administer a policy affecting interests with individual but possibly conflicting priorities. Training and formal education provides a key, enabling experience and exposure to etch the features of character. The sharing of these experiences, through the written and spoken word, contributes to one’s store of information and so enhances the chance that any decisions made will offer the optimum solution to a problem. The removal of one species to foster another may ignore the interdependence of plant and animal communities. The erstwhile forester who fought off marauding locals to convert a useless jungle into a fine uniform stand of utilizable timber might be surprised to find his equally professional modern counterpart devoting much of her energies to the welfare of the ‘forest rascals’, nurturing the food plants which contribute to their well being.

Foresters have a long tradition of conservation. In the USA, the fourth Forest Service strategy, Multiple Use- Sustained Yield Act (1960) states that ‘It is the policy of the Congress that the national forests are established and shall be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes. The purposes of this Act are declared to be supplemental to, but not in derogation of, the purposes for which the national forests were established as set forth in the Act of June 4, 1897’ — the Organic Act. In 1978, the US Supreme Court in the case known as US v. New Mexico (438 US 696) found that whilst the Forest Service could utilise water from the Rio Mimbres for the purposes of maintaining timber supplies, if they wanted water for stock watering, for fisheries, wildlife, aesthetics and recreation in the Gila National Forest, they would have to apply for it through State Water-Rights Procedures and other claimants might have priority. (See Journal of Forestry, June 1985)

Many areas of forest and wilderness would have disappeared without the ministrations of forestry departments but in the State of Victoria, Australia, the conservation lobby appears to have encouraged the government to bring all the public land management departments under one ‘hat’— the Department of Conservation, Forests and Lands. The corporate management team has a Director-General and directors for Regional Management, State Forests and Lands Service, National Parks, Land Protection, Fisheries and Wildlife, Corporate Service, Policy Co-ordination and Strategy, Human Resource Management, Financial Management and Economics. The previous chairman of the Forests Service was removed from office. It will be instructive to see how the new team reconcile the diversity of interest.
Around the Worlds

The editor is always pleased to receive items of interest from around the world but in the recent copy of 'Pravda', it would have helped if the significant section could have been indicated. Unfortunately we have insufficient space to publish Conference Reports in full and regret that there may appear a temporary surfeit of 'geography', but some do appreciate the reminder of a location and the thought that uninhabited islands still exist.

Voluntary Service Overseas

During September, 5 foresters obtained employment, starting work in Uganda, Granada and the Gambia. Their positions involve forest inventory, planning, management and rural community forestry.

Volunteers are needed for January, 1986 to work in Sudan, Kenya, Tanzania and Ghana on community Forestry Development and forest planning. Interested qualified foresters should contact the ‘Agricultural Desk’, VSO, 9 Belgrave Square, London SW1X 8PW (01-235-5191).

The Ninth World Forestry Congress

The Congress was held in Mexico between 1 and 10 July, 1985. There were 2,200 delegates from 105 countries. The recurrent message from speakers from the tropics and sub-tropics was that population pressures were resulting in the clearance of forests for subsistence farming, for fuelwood and for ranching. The subsequent deterioration in the climate and productivity of the soil would lead to even greater demands being made upon the diminished forest resource. New plantations, providing domestic and industrial fuelwood, can extend the life of indigenous forests. New plantations in arid and semi-arid areas can help to counteract or mitigate some of the adverse characteristics of climate. New plantations in timber-consuming temperate countries can help improve their own balance of payments and reduce the pressure on the world's natural forests.

The Congress recognised the role that forests could play in sustaining water supplies and wildlife habitats. It was also appreciated that subjects such as atmospheric pollution, forest fires, pests and diseases required national and international attention.

Assistant Secretary

Judy Bromiley has played an integral role in the Association’s affairs for the last seven years, bringing efficient and calm order after four Assistant Secretaries helped out for non-consecutive periods earlier in 1978. The editor/secretary joined a well organised ship towards the end of 1981 and has since enjoyed continuous, cheerful, careful, considerate co-operation. Some of the Association members bade farewell at the AGM dinner and presentation. Several Executive Committee members attended a luncheon during the final week before her retirement. We wish her well on her visit to Victoria and New South Wales to visit a younger married daughter and for the subsequent four months in North and South California visiting her married son, her elder daughter, son-in-law and three grandchildren. We shall expect some copy for the ‘Around the World’ section upon her return.

Our new Assistant Secretary, Wallace A. W. Hockey, is married with an adult family of four. He matriculated from Rondebosch High School, received a certificate in
Education from Westminster Teachers Training College and has an Oxford B.Ed. He has worked in South Africa and for 10 years in Taiwan with the Overseas Missionary Fellowship and has spent the last 14 years in the UK, his teaching including Geography. His fluent Chinese, whilst discussing the ‘Yellow Dragon and Green Ocean’ paper in this issue should ensure that at least our Chinese Summary is the correct way up.

Summer Meeting

Members, who were able to attend the spring meeting of the AGM in Scotland, had the opportunity of taking part in a full programme of forestry visits and hospitality. The Association was kindly offered a summer bonus by being invited to a joint meeting with the Royal Forestry Society, EWNI. This was held on the 3 June, 1985 at the Gaddesden Estate in Hertfordshire. Our host, Nicholas Halsey, conducted a party of about 50 members and friends from the two organisations around the 100 ha of woodland on the 800 ha estate. The choice of timber species being grown was influenced by the depth of clay which overlay the chalk of this part of the Chilterns. The thin soils favoured beech (Fagus sylvatica); ash (Fraxinus excelsior) would regenerate well but needed deeper soils to thrive and such prime deeper soils as were not in agriculture were planted with oak (Quercus robur). These broadleaved species might be established with conifer nurse species such as Norway spruce (Picea abies), European larch (Larix decidua) and thuya (Thuya plicata). Two individual conifers which had been allowed to grow to maturity were the subject of a competition to assess their volume. This was expressed in imperial measure for the benefit of some RFS members. The CFA secretary’s suggestions for these two pines (Pinus nigra, laricio) at 128 and 175 H ft³ were within 5%, earning a tactful second prize. During lunch, which was held in the grounds of the Golden Parsonage, members had the opportunity of inspecting a static display of safety equipment by Hyett Adams. One of the questions raised during the afternoon was the refurbishing of a lime (Tilia × europaea) avenue originally planted in 1717. Further hospitality from our host concluded a splendid day, blessed with continuous sunshine in a week which suffered more than the month’s ration of rain.

Autumn Meetings

On Wednesday 18 September, 1985, there will be a business meeting at 6 p.m. in the Empress Hotel, Victoria with the chair being taken by Vice-President Christopher Latham.

On Thursday 19 September, 1985, the Association will host a reception at 8 p.m. at the Oak Bay Beach Hotel. Further information on these meetings will be on the Association's static display in the Empress Hotel.

On Thursday 17 October, 1985, the Executive Committee will meet at the Timber Research Station, Princes Risborough (10.45). The afternoon meeting will visit the High Wycombe interests of James Latham Plc. Any members interested in further details are asked to contact the Secretary.

Schlich Award

It was decided that the prize should continue to be awarded to Forest Departments, Institutions or organisations chosen from around the world for “outstanding achievements in Forestry and/or Forest Management”. The award should be made every 5th year at the Commonwealth Forestry Conference to the successful organisation selected by the Trustees of the Schlich Memorial fund. The award would be in the region of £400 and would be divided between the host country and the successful nominee.
ECONOMIC FORESTRY GROUP's Spring Luncheon

Douglas Badham, EFG Chairman, welcomed influential guests to their Forestry Luncheon at the Grosvenor House Hotel in London. The reply, on behalf of the guests, was by Mr. Stanley Clinton-Davies, UK EEC Commissioner for Forestry and the Environment. He made the points that the Community's deficit in wood in 1983 had reached £8.5 billion, a cost only second to that of energy. The EEC wood industry employed 1.5M people, 5% of all the industrial jobs in the Community. Imports of wood by the UK were costing over £4,000M annually but at least the increasing quantities of timber being grown and the new forest industries which could come on stream in 1985 should show savings of over £200M in import substitution for 1986.
Left to right (standing)

1. Rt. Hon. R. Whitney, MP
   Parliamentary Under-sec of State, Min. of Health & Social Security
2. John Perrott, Director EFG
3. Rt. Hon. Lord Taylor of Gryfe, former Chairman EFG
4. John Roberts, Director EFG
5. Hon. D. A. C. Douglas-Home, Director EFG
6. Ian MacGregor, Chairman NCB
7. E. J. G. Smith, Dep Sec. M.A.F.F.
8. G. D. Hutchinson, Forestry Commissioner
9. Andrew Jennings, Director EFG
10. Maj. D. Davenport, Chairman Council for Small Industries in Rural Areas
11. Rt. Hon. Lord Lyell, Minister of State, N. Ireland Office
12. Lord Gibson-Watt, Forestry Commissioner
13. A. R. Williams, Chief Exec. TG UK Ltd.
14. T. M. Sutton-Mattocks, Director EFG
15. David Cooper, Director EFG
16. M. T. Rogers, Commonwealth Forestry Association
17. A. A. T. van Rhign, Delegate Director-General, Industry Brussels
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20. C. Baillet, Head of Division, Agriculture Brussels
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Left to right (seated)

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27. John Campbell, CE, EFG
28. Rt. Hon. Nicholas Edwards, Sec of State for Wales
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34. Keith Geddes, Director EFG
Diploma in Timber Studies at High Wycombe, UK

The one year Diploma in Timber Studies course at High Wycombe, UK was successfully concluded on July 5th when eleven students from overseas countries were among those who graduated. The Diploma was awarded to the following:

Dania Goyog (Sarawak) utilisation; Edward Foo (Sarawak) drying; Sairusi Bulai (Fiji) drying; Jamael Karundu (Kenya) furniture production; William Masterton (Jamaica) utilisation; Natalis Okeny (Sudan) saw milling; Mkubwa Seif (Zanzibar) saw milling/saw doctoring; Jayakody Rupasinghe (Sri Lanka) saw milling/saw doctoring; John Bori (Papua New Guinea) utilisation; Floriano Chiphala (Malawi) furniture production; Daniel Mpanda (Zambia) wood based panels.

Messrs. D. Goyog, E. Foo, S. Bulai and J. Bori were awarded the Diploma at First Class Honours level.

Tom Gill Award

At the joint meeting of the Governing Council and the Executive Council held in April 1985 at Bush House, Penicuik, Scotland, it was decided that from 1986 a medal would be given annually to a young person, alternatively from the ‘developed’ and ‘developing’ world for “a significant contribution to progress in forestry or wood science.” Every 5th year an accumulated cash prize and a Tom Gill medal will be awarded to the outstanding contributor among the four previous medal winners or to any other successful nominee. The medal would be presented at the Commonwealth Forestry Conference. The nominations for this award will be sought through Local Honorary Secretaries.
Dear Editor,

I'm writing to ask for your advice and assistance, at the suggestion of the CFI librarian. I'm a social anthropologist with research interests in the Indian part of Western Himalaya, where I did fieldwork for my Ph.D among shepherding pastoralists in Himachal Pradesh between 1976 and 1980. One of the issues I've been examining (and writing about) concerns the part played by such pastoralism in the long-term deforestation and ecological degradation of the Himalaya. In this connection I am extremely interested in the condition of forests and grazing pastures in the mid-Himalayan ranges and the lower hills in earlier decades, going right back to the early British period in the second half of the 19th Century.

To this end, I'm keen to trace people who might be expected to have in their possession photographs from the pre-1947 era which depict the extent and condition of forest and 'wasteland' in the districts and states of the eastern part of what used to be called the Punjab Himalaya. Essentially, I am looking at Chamba, Kangra, Kulu and Mandi Districts, and perhaps Simla to a lesser extent.

The obvious and ideal people would seem to me to be former IFS officers (or their immediate families), and I'm hoping you might be able to communicate my interest to other members who could help me with old photographs of the region.

Any assistance which can be offered would be much appreciated.

Yours truly,
Dr. Peter Phillimore
(currently, Research Associate, Univ. of Bristol)
Nicholas Banister, Retiring Deputy Surveyor of the New Forest received the OBE in the Queen’s Birthday honours.

Alan Eddy is the Association’s incoming Local Honorary Secretary (HS) in Victoria, Australia. At the AGM in Scotland, it was Dr. Frank Moulds who brought us the sad news of the death of Kenneth Simpfendorfer who had been the Association’s LHS for the previous 20 years.

Dr. Bekele Gessesse has joined the Forest Resources Development Project as Foreign Consultant. He is based at the University of Sri Jayewardenepura, Nugegoda, Sri Lanka. This position was previously held by Dr. Don Harding who has now returned to UCNW, Bangor as Lecturer in the Department of Forestry and Wood Science.

Dr. John B. Hall was formerly Professor of Forestry at the University of Dar-es-Salaam, Tanzania and who previously taught at the universities of Ife and Ibadan in Nigeria. He has been appointed Lecturer in Tropical Forestry at the UNCW, Bangor, North Wales.

James Henderson, senior lecturer in forestry at the University of Aberdeen, has been elected president of the Royal Scottish Forestry Society. He served in Nyasaland (Malawi) from 1951 until 1964.

His Royal Highness, The Duke of Kent, has agreed to become Patron of the Tree Council.

Christopher Latham, past Chairman of the Association and past President of the Timber Trades Benevolent Society, succeeds Terence Mallinson as Chairman of the Timber Trades Training Association.

Mr. L. I. Leontiades has been appointed Director of the Department of Forests in Cyprus and has agreed to act as the Association’s Local Honorary Secretary following Mr. E. D. Michaelides.

Alan Miller writes from Quito that in addition to carrying out a little forestry consultancy work and the odd appreciation of climbing conditions in the upper Andes, he prospects in the higher reaches of the Amazon and is carrying out assessments on the comparative distribution of sand grain particles on various tropical beaches.

Dr. William E. S. Mutch, immediate past-president of the Institute of Chartered Foresters and head of the forestry department at Edinburgh University received the OBE in the Queen’s birthday honours.

Dr. R. E. Pawsey leaves Oxford again in October to join the staff at the Department of Forestry at Aberdeen University. He has a two year engagement as Senior Lecturer in Forest Pathology. Stan Murray retired from the post this year. Dr. Colin Millar was to have taken over this responsibility but he has been granted two years leave of absence whilst he acts as IVS Director of Forestry Co-operatives in Botswana.
Professor F. L. C. Reed has accepted the Association’s invitation to act as Local Honorary Secretary in British Columbia. Appreciation is expressed to Ivor Burrows for his service as LHS and good wishes offered for his retirement.

John Wholey has been the Association’s LHS for the last five years in Hong Kong and now has a temporary address at 79 Ashdown, Eaton Road, Hove BN3 3AR, East Sussex, England. We reciprocate John’s wishes of ‘Kung hei fat choy’ but trust he realises that any prospering is likely to be spiritual rather than material. The responsibility for the Association’s local interests has been accepted by Mr. Iu Kow Choi in the Agriculture and Fisheries Dept. Kowloon.

Deaths
STEWART, D. W. R., 1 King’s Park Avenue, Crawley WA 6009, Australia — on 15th June 1985 — aged 77.

OBITUARIES

Kenneth Simpfendorfer. B.Sc.
We were saddened by the untimely death from cancer at the age of 62 of W. K. J. Simpfendorfer who had been a very active Victorian (Australia) correspondent for this Association for nearly 20 years.

Following graduation from the Victorian School of Forestry, Ken spent a number of years practising the art of forestry with the Victorian Forests Commission, with the major emphasis on softwood plantations. It was in the silviculture of introduced softwoods and nursery practice that he specialised for many years.

Ken subsequently returned to study at Melbourne University where he completed the B.Sc.F. course, and later became Chief Superintendent of Plantations at the height of a boom in plantation activities and increased development of nurseries. At his death he held the position of Special Projects Officer for the Victorian Forests Commission.

Ken also found time to complete an external Masters degree, to give time to his Church and to become a prominent member of the Institute of Foresters of Australia.

He is also the author of a major reference book which has found its way on to the shelves of many foresters and garden lovers — its title is “An Introduction to Trees for South-Eastern Australia”. A second revised edition was completed before Ken’s death and is now with the printer together with a companion volume which he wrote in the form of a Key to the trees and shrubs of south-eastern Australia. These will be monuments to a distinguished scientist and forester.

His botanical and silvicultural knowledge made him ideally suited to visit Jiangsu Province in China which he did on three occasions since 1982 to strengthen the cultural and forestry ties between the “sister states” of Jiangsu and Victoria. He has helped to establish in China plantations a number of eucalypts and other appropriate species and to teach suitable nursery procedures, as well as introducing Chinese trees into the Olinda Arboretum near Melbourne in which he has taken a keen personal interest since its inception.

Ken Simpfendorfer enjoyed his life’s work in forestry and in travels off the beaten track: for example he undertook several trekking excursions to Nepal.

He was a quiet achiever. He will be missed by his many friends in Australia and overseas.

Dr. F. R. Moulds
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AT BUSH ESTATE, ROSLYN, SCOTLAND ON 19 APRIL 1985

Given by R. T. Bradley,
Divisional Head of Harvesting and Marketing, Forestry Commission, UK

THE UK TIMBER INDUSTRY

Introduction

I was at some point asked by the Chairman to speak about the forest industry in Scotland as we have held our AGM north of the border this year. On reflection, however, I felt that the Scottish scene was at the moment so heavily influenced by activities south of the border that it would be difficult to restrict discussion to Scotland. Nevertheless I will concentrate mainly on the Scottish situation when I come to discuss supply and demand in the second half of this address. The first half of this paper comprises the formal statement which is to be presented to the 12th Commonwealth Forestry Conference in Canada in September and provides a useful background to the main subject of this address.

The UK Timber Industry

The United Kingdom relies heavily on imported timber and timber products. In 1983 the total cost for all wood products, including paper and board, was £3,833 million; (this represents some 90% (in value) of the timber and timber based products used in the country.) All products, apart from wood pulp and waste paper showed rises in both the amount imported and their value over the review period (Table 1). The substantial increase in total value of imports in 1983 compared with 1982 follows two years of more modest increases and represents a degree of restocking as the economy recovered from the recent recession.

The sawn softwood and hardwood produced from UK forests in 1983 was 1.8 million m³ or 18% of total apparent consumption of sawnwood. There was a continuing increase in the volume of softwood sawlogs milled between 1980 and 1983 but this was offset by a reduction in supply of hardwood logs. The production of small diameter roundwood for round mining timber and the manufacture of wood based panel products as well as paper and board has remained steady over the past four years reflecting as much as anything the present lack of domestic manufacturing capacity. Exports of pulpwood to Scandinavia are providing a useful temporary outlet (Table 2).

Employment in the wood-processing industries (including sawmills; and pulp and board mills) wholly or partly using British timber was 10,920 in 1983. In addition about 15,000 persons were employed in further simple processing (machining, re-sawing, planing) of imported timbers. Total employment in paper and board mills and timber and timber processing (including particleboard, fibreboard and plywood, but excluding joinery and forestry) was a little over 70,000.

Employment in the timber-using industries is dominated by that in the secondary processing and manufacturing industries, such as construction and joinery, furniture, shop-fitting etc.; however, the numbers employed, 202,000 in 1982, or 246,000 if the paper and board industries are included were substantially down on the corresponding figures for 1978, at 251,000 and 316,000 respectively.
Table 1
United Kingdom Import of Timber and Timber Products, 1980–1983

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Round and</td>
<td></td>
<td>4.3MT</td>
<td>3.8MT</td>
<td>4.3MT</td>
<td>5.1MT</td>
</tr>
<tr>
<td>Sawn wood</td>
<td></td>
<td>6.7Mm³</td>
<td>5.9Mm³</td>
<td>6.8Mm³</td>
<td>8.1Mm³</td>
</tr>
<tr>
<td></td>
<td></td>
<td>£688M</td>
<td>£602M</td>
<td>£672M</td>
<td>£937M</td>
</tr>
<tr>
<td>Wood manufacturers and reconstituted wood</td>
<td></td>
<td>1.5MT</td>
<td>1.6MT</td>
<td>1.6MT</td>
<td>1.9MT</td>
</tr>
<tr>
<td>(includes panel products)</td>
<td></td>
<td>£359M</td>
<td>£435M</td>
<td>£428M</td>
<td>£569M</td>
</tr>
<tr>
<td>Wood pulp and waste paper</td>
<td></td>
<td>2.1MT</td>
<td>1.8MT</td>
<td>1.5MT</td>
<td>1.7MT</td>
</tr>
<tr>
<td>Wood pulp and waste paper</td>
<td></td>
<td>£392M</td>
<td>£428M</td>
<td>£401M</td>
<td>£420M</td>
</tr>
<tr>
<td>Paper and board</td>
<td></td>
<td>3.9MT</td>
<td>4.4MT</td>
<td>4.4MT</td>
<td>4.8MT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>£1,288M</td>
<td>£1,537M</td>
<td>£1,678M</td>
<td>£1,906M</td>
</tr>
<tr>
<td>TOTAL VALUE</td>
<td></td>
<td>£2,727M</td>
<td>£3,001M</td>
<td>£3,179M</td>
<td>£3,833M</td>
</tr>
</tbody>
</table>

[Sources: HM Customs and Excise TTF Statistics]

Table 2

<table>
<thead>
<tr>
<th>Category</th>
<th>YEAR (vol. x 1,000 m³)</th>
<th>1980</th>
<th>1981</th>
<th>1982</th>
<th>1983</th>
</tr>
</thead>
<tbody>
<tr>
<td>Softwood sawlogs</td>
<td></td>
<td>1640</td>
<td>1670</td>
<td>1865</td>
<td>1875</td>
</tr>
<tr>
<td>Hardwood sawlogs</td>
<td></td>
<td>940</td>
<td>945</td>
<td>715</td>
<td>580</td>
</tr>
<tr>
<td>Round pitwood</td>
<td></td>
<td>145</td>
<td>145</td>
<td>130</td>
<td>120</td>
</tr>
<tr>
<td>Chipboard and fibre building board</td>
<td></td>
<td>220</td>
<td>245</td>
<td>215</td>
<td>275</td>
</tr>
<tr>
<td>Paper and paperboard (of which exported)</td>
<td></td>
<td>600</td>
<td>855</td>
<td>830</td>
<td>765</td>
</tr>
<tr>
<td>Other industrial wood</td>
<td></td>
<td>(210)</td>
<td>(590)</td>
<td>(555)</td>
<td>(430)</td>
</tr>
<tr>
<td>NI Production (undifferentiated)</td>
<td></td>
<td>285</td>
<td>275</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>Total industrial wood</td>
<td></td>
<td>3890</td>
<td>4200</td>
<td>3965</td>
<td>3850</td>
</tr>
</tbody>
</table>

[Source: Forestry Commission and NI Forest Service]

The sawmilling industry converting home-grown logs employed just under 6,400 persons in 1983, only two-thirds of the number employed in 1977 though the out-turn of sawnwood in the two years was at a comparable level. The number of mills operating fell from 532 to 455 in this period. A large number (381 or 84%) of the mills operating have a log intake of less than 10,000 m³ per year and the substantial reduction since 1977 in the number of mills operating has largely been in this small-mill category (Table 3); 58 mills have a log intake exceeding 10,000 m³ per year but in only 16 mills does the log intake exceed 25,000 m³. The larger mills, with a log intake of 10,000 m³ or more, amount to 16% of the total number but produce 64% of the total out-turn. Currently (August 1984) there is a considerable investment in a number of sawmills which will enable the industry to utilise the steady increase in supply of softwood sawlogs which is forecast to come from UK forests.
Table 3
Number of Sawmills in the United Kingdom

<table>
<thead>
<tr>
<th>YEAR</th>
<th>INPUT (m³ over bark/year)</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>&lt;10,000</td>
<td>10,000–25,000</td>
</tr>
<tr>
<td>1983</td>
<td>381</td>
<td>58</td>
</tr>
<tr>
<td>1977</td>
<td>465</td>
<td>50</td>
</tr>
</tbody>
</table>

[Source: Forestry Commission and NI Forest Service]

The wood-based panel industry in the UK is concerned mainly with particleboard production, though fibreboard and a very small volume of plywood is also produced. One mill peels imported logs for veneer which is supplemented with imported veneer for plywood production and a further three mills slice imported logs for decorative veneers. Seven particleboard mills are in operation with an annual output, in 1983, of about 520,000 m³, or about 25% of the national use. Three mills produce conventional types of fibre building board and in one particleboard mill there is a line producing medium density fibreboard (MDF). The total production of these mills for the UK market in 1983 was nearly 48,000 T and compares with an import of 227,000 T. There was an export, believed to be of the order of 15,000 T, of MDF.

Three mills in the UK manufacture pulp using small roundwood; three others have ceased production in the period under review though two continue to manufacture paper using bought-in pulp.

Since 1980 there has been a dramatic restructuring of the wood-using industry in the United Kingdom. In that year, 3 pulpmills closed with a loss of 500,000 T small roundwood capacity. The forest industry responded by switching to exports as a temporary measure in order to maintain the harvesting resource and to give the wood-using industries time to re-organise. In addition to these closures one particleboard mill closed but was re-equipped and re-opened following a change of ownership.

As a result of close co-operation between growers, both state and private, and industry, substantial progress has been made to ensure that the maximum benefit is derived from the increasing supplies of timber becoming available. By mid 1985 additional capacity installed or planned in the wood-based panels and the paper and board sectors will amount to approximately 935,000 T. These include two new particleboard lines with coating facilities, a new Orientated Structure Board Mill (OSB), a new pulp and newsprint mill and a new cartonboard line. To this extra capacity must be added the expansion of the sawmilling industry already mentioned. The overall effect will be to curtail the need to export industrial wood and to provide a sound manufacturing base for the future.

The Supply and Demand Situation

The net result of these new industrial developments was described in a paper presented to the recent Institute of Foresters Conference in Edinburgh which covered the overall GB situation and in more detail the situation in England and Wales. In this paper I intend to take the review a stage further and look at the situation in Scotland in more detail.

As already mentioned in the official report above and in the earlier paper, the supply and demand situation for sawlog material throughout the UK is more or less in balance. This is achieved to some extent by the balancing mechanism of minimum top diameter and to a lesser extent, length. In the borders of England and Wales where the demand
for sawlogs is very strong the minimum top diameters and lengths are much smaller than they are in other parts of the country such as Scotland where the demand is weaker. This is of course a gross generalisation and encompasses many local exceptions where because of new sawmilling technology or because of a strong pallet wood market for example, the top diameters and lengths for this so-called ‘bar’ or ‘pallet log’ material is much the same as in the English and Welsh borders.

Nevertheless, whatever the localised exceptions, it is broadly true that growers can sell all the sawlog sized material they can produce, however this may be defined in top diameter, length and other quality terms appropriate to the locality. This means that we can simplify our examination of supply and demand by restricting it to the small wood sector as long as we remember the regional small differences in top diameter and length requirements as determined by the sawmill industry. In the first instance, however, it is simplest to assume the conventional definition of small wood, namely all the volume to 14 cm top diameter overbark plus half the volume between 14 and 18 cm overbark. For the reasons discussed above this will tend to marginally overestimate the small roundwood available in England and Wales and perhaps to underestimate it in parts of Scotland.

Small Roundwood Demand and Supply in England and Wales

The graph of supply and demand for England and Wales shows the sharp increase in demand which results from assuming that all the new developments are to be supplied from English and Welsh forests (the ‘Nominal’ Demand) (Table 4). The curve for ‘Adjusted’ Demand shows the more probable demand after adjustments for supplies likely to be attracted from Scottish forests have been allowed for.

![Graph showing supply and demand estimates for England and Wales](chart.png)

**Table 4**

<table>
<thead>
<tr>
<th>Year</th>
<th>Potential Supply</th>
<th>Total Consumption</th>
<th>Exports</th>
<th>Domestic Consumption</th>
<th>1982 Forecast</th>
<th>Nominal Demand</th>
<th>Adjusted Demand</th>
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<tbody>
<tr>
<td>1980</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
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Note: Exports and Domestic Consumption are shown as percentages of Total Consumption.
The dotted line drawn back from the shoulder of this curve through the middle of the actual consumption figures for the early 1980s lies roughly parallel to the supply line which indicates that this rate of increase is realistically achievable. The gap between these parallel lines is assumed to represent first of all that part of the private sector potential supply which is unlikely to come on to the market and secondly the fact that the actual diameter limit for 'bar' material in England and Wales is less than that implicitly assumed by the conventional definition of small roundwood.

The other feature shown by the graph is the likely disappearance of exports of small roundwood from English and Welsh ports. Since the graph includes all species it tends of course to obscure somewhat different situations in the main species groups. Spruces will tend to be in stronger demand than pines if only because the pine-using chipboard mills are not well located in relation to one of the main pine growing areas at Thetford. Shortages in other areas may, however, justify longer haulage distances which will tend to mop up supplies from these areas with poor local demand.

Small Roundwood Demand and Supply in Scotland

The situation in Scotland differs from that in England and Wales (Table 5). Firstly because of the projected exports to England and the tailing-off of adjusted total consumption as the English and Welsh forests increase production to meet the major part of the English and Welsh demand. Secondly it is interesting to note the much closer correlation between potential supply and past total consumption. Since the FC actual production is very close to the potential throughout GB the difference must lie with the private sector which must be producing a greater proportion of potential production than in England and Wales.

Table 5

![Graph of Small Roundwood Supply and Demand Estimates for Scotland]
The net result is that the adjusted total consumption curve at its maximum in 1988 will absorb a lower proportion of potential supply than has been the case in recent years. In fact the assumption that overseas exports are likely to tail off by 1987 may be inappropriate and if demand from Scandinavia continues at its present level it is likely that overseas exports will continue to form a significant part of total consumption and that the proportion which this bears to potential production will remain much as it is at present.

The interesting thing is that despite the exports of both small roundwood and sawlogs to England in the next few years there is still going to be an increasing proportion of potential production which is available for new developments or for expansion of existing industry from 1988 onwards. The problem for bodies like the Scottish Forest Products Development Group whose job is to co-ordinate development work is to encourage the most appropriate timing of all types of development and the location of new developments to suit the species and other requirements of industrial developers.

**Implication For New Developments**

While in Scotland the overall picture looks reasonably hopeful for further developments in the small-wood-using sector, it becomes more difficult as specific locations are considered from the point of view of wood supply within an economic haulage distance. If the species requirements are at all restrictive the problem increases and a delay is often necessary before the supply builds up to the required level.

From this it follows that industries such as sawmilling, because of their relatively small volume requirements and lack of severe species restrictions, are in a better position to exploit the increases in potential production. The board mill sector is next in order of the ease with which new developments, whether expansions of existing plant or new sites, can be fitted into the evolving supply and demand picture. Pulp mills lie at the other extreme of difficulty and even the new relatively small CTMP plants because of their species limitations as well as their total wood requirements will almost inevitably involve some disruption of the existing markets. This is unavoidable even if the timing of such developments is planned to take place as adequate new supplies become available. The reason is that the lead-in time is so long for a project of this size that erosion of the new supplies takes place because of developments in local markets or increases in capacity of existing industries between the time that the decision is taken and the time the mill becomes operational. This is a cost that has to be balanced against the price advantages which the pulp industry can offer to wood producers. Against this has to be balanced the fact that if plants like this close for any reason the impact is very considerable, as we experienced with the Wiggins Teape pulp mill at Fort William. Our experience of developing alternative exports markets, while reassuring, cannot be guaranteed to work again, nor is it a solution which has great nationalistic appeal.

Thus while large-scale potential developments are encouraged the encouragement is tempered with caution and at the other extreme we rely on the home sawmilling trade to fill in the interstices of the developing supply position without overseas advertisement and without the benefit of contractual arrangements for wood supply. Experience has proved that over the whole size range our development policy has been very successful to date.
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Various planting programmes have different priorities. In the Chittagong Hill Tracts, an Asian Development Bank scheme on land with slopes of over 45° aims to control erosion and distribute rainfall run off over long periods. SIDA is aiding the establishment of 4,046 ha of soft broadleaves for the pulp and paper industry. The World Bank is helping with the establishment of 44,500 ha of mangroves. Extension forestry is encouraging the planting of trees for fruit, fodder and fuelwood with an initial programme involving 25,000 homesteads. High yielding and fast growing species include Eucalyptus camaldulensis, Acacia mangium and Albizia moluccana. There is insufficient firewood to satisfy the demand for fuel. Using the energy equivalent of coal as a common denominator, the consumption of natural materials for fuel used annually over the 1980–82 period was 8.4M T. Expressed in millions of Tonnes, rice hulls supplied 1.85, rice straw 1.5, jute sticks 0.4, Bagasse 0.6, cow dung 1.55, firewood 1.5 and others 1.0. There are potential advantages to agriculture if timber can replace some of the other organic materials, allowing them to be used for soil improvement.

A further 0.9M T of firewood is used in the tobacco and brick industry and boat building would bring this total up to 1M T. Other industries which consume 1M T of timber are the veneer and plywood — just under 0.7M T, pulp and paper — 0.25M T and the match factory with its requirement of about 55,000 T. The wood based export market includes about 7,500 T of paper and 22,000 T of newsprint. During 1982, China imported about 1,000 m³ of teak (Tectona grandis). Timber contributes about 2.4% to the GNP.

BRUNEI

Anderson and Marsden (Forestry Consultants) Ltd. have recently completed a study of the Brunei forest resources for the Brunei government and Shell International PLC and have kindly forwarded details from which the following notes are compiled.

In the sixteenth century the Sultanate of Brunei controlled much of Borneo. The land area, including mangrove swamps, is 576,500 ha with undisturbed primary forest covering 341,200 ha (59%), disturbed forest covering 127,700 ha (22%). Forest Reserves cover 39% of the land area — 57% of the primary forest; the consultants recommend these respective figures be increased to 55% and 80%. The primary forest is 56% mixed dipterocarps, 27% peat swamp and mangrove, fresh water swamp, heath and montane forest each contributing slightly less than 5%.

The major part of the peat swamp and mixed dipterocarp forest is expected to continue to supply domestic requirements for sawn timber, about 100,000 m³ annually. There is the possibility of future indigenous plywood manufacture but little or no export of timber is envisaged. Even without an export programme, a temporary deficit in hill forest logs
is forecast around 2015. The consultants strongly discourage any wide scale felling which a pulp or other major wood based industry might suggest.

The government is concerned with the protection of water catchments and 17% of the forest is designated as either Protection or Conservation Forest. Mixed dipterocarp forest abutting the neighbouring Gunong Mulu National Park in Sarawak, Malaysia, has been designated as has 35,300 ha of mixed dipterocarp and montane forest in the rugged south eastern portion of the Temburong District.

The consultants consider that some investment in plantations now could ensure that adequate supplies of timber would be available to bridge the forthcoming shortage but express no great enthusiasm for any massive plantation establishment. Revenues from the oil industry raise the expectations of the local labour force and the logging and timber industry already need to engage staff from outside the country for 80% of their requirements. Silvicultural management of the Shorea albida peat swamp forests and other existing commercial species should enable the forests to provide the majority of the country’s domestic requirements in perpetuity.

CYPRUS

Forest covers 19% of the island’s surface. The State owns 161,258 ha, 1,668 ha is owned communally and 13,577 ha is owned privately. The specie responsible for 90% of the volume of timber is Pinus brutia with an estimate of just over 2.5M m$^3$ and a 10 year period increment of just under 0.5M m$^3$ with an allowable cut giving a small rise in growing stock. Too many of the trees are mature or over mature but the forests are understocked. Natural regeneration is proving inadequate and before any clearing of older trees, resources for replanting must be available. The forest area makes a major contribution in watershed control in the two mountainous regions of the Troodos and Pendadactylos Ranges. Of the 1,000 mm rainfall in the Southern mountains, 850 mm falls between November and March but is still contributing during the summer to the ground water of the plains, where total rainfall is only 250 mm. The forests also provide a valuable environment for tourism and recreation; one in three on the island are car owners. There is now far less deliberate burning of the forest, either as a political gesture, to improve the grazing for farmers’ goats or to enhance immediate supplies of firewood. Over 13,000 m$^3$ of timber is used for fuelwood and charcoal each year and is so popular that the prices paid are higher than the equivalent costs for heating by gas or electricity. Village woodlands created for fuel supplies with exotic species such as Acacia cyanophylla and various Eucalypts are now appreciated for their amenity and the range of species is being increased. Pinus brutia grows from sea level up to 1,500 m, above this height, Pinus nigra grows up to the elevation of 1,952 m on the top of Mount Olympus. Cedrus brevifolia is indigenous and has areas reserved for its benefit, another conifer met is Cupressus sempervirens. Broad leaved species include Platanus orientalis, Alnus orientalis and Quercus alnifolia, the latter growing as an understory to the pine. Game Reserves include 60,000 ha managed for the moufflon, Ovis ammon orientalis Cyprius. The annual volume of home produced wood based products is about 57,000 m$^3$; the value to the GNP represents 1%. Additional annual imports of wood goods cost around £23M.

The island has a Forestry School which offers a two year diploma. The 72 students include 20 from overseas. The Forest Department has a staff of under 300 including executive, clerical and technical. There are some 228 forest workers and a further 65 on private contractor’s work. These figures compare with 404 and 280 for 1979 when the establishment programme was coping with the areas burnt during the fighting. The plantation area is now 17,500 ha.
ECUADOR

(Allan Miller has kindly forwarded a short note to give members some idea of the country.)

Forestry in Ecuador includes both wet and dry lowland tropics, through intermediate altitudes to the wet and dry highlands, the Andean mountains supporting indigenous timber species up to about 3,500M and descending to the east of the mountains, the edge of the Amazon basin known as the ‘oriente’.

Selective exploitation of tropical hardwoods is conditional — or should be — on replanting of approved species. The favourite species have been *Cordia alliodora*, *Tectona grandis*, *Schizolobium parahybum* and *Pinus caribaea*.

In the Sierras, farming takes precedence over forestry up to about 3,500M. The native vegetation at this altitude is a scrub of *Buddlia incana*, *Berberis virgata*, *Polylepis incana* and other species including those of *Gynoxis*. Up to about 3,600M there has been large scale and moderately successful planting with *Pinus radiata*. Some of this is now approaching 15 years old and the target area envisaged was 50,000 ha to supply a pulp mill which in turn would make liner board for the banana industry and reduce dependence upon the $100M being spent annually on pulp imports. The recent arrival of *Dothistroma pini* is causing some worry which may result in future plantings using more *Pinus patula* and *P. muricata*.

Between 2,000 and 3,000M *Eucalyptus globulus* is immensely successful both silviculturally and commercially. Many other Eucalypts are being assessed and promising results are being obtained with *E. deglupta* in the wet lowlands.

In many parts of Ecuador there are substantial areas owned by villages and co-operatives. The government encourages forestry schemes by giving free technical advice and low interest loans. Agro-forestry has become increasingly popular during the last decade with the young trees being grown in conjunction with vegetables and later offering shade for cattle and in the case of *Leucaena leucocephala*, much needed protein for them. In the arid areas, there is an increasing awareness of the need to establish tree cover just to limit the eroding effect of the wind.

There are tremendous possibilities for successful forestry operations in Ecuador but these would require substantial capital, which might be available, and numerous trained foresters which are at present in short supply.

GHANA

The area of Ghana is 23,854,000 ha of which 15.63M ha is savannah and 8.23M ha (34.5%) is forest. Forest reserves cover 1,678,800 ha of closed forest and 880,600 ha of savannah. During the period from 1979 to 1984, 60,300 ha of unreserved forest was transferred to the category which includes farm land, cocoa and bush fallow. The population is 12,205,574. Exports of *Khaya* and *Entandrophragma* species were recorded from 1888 with 84,900 m$^3$ being shipped to England in 1913. Much of the road network in the south of the country is based upon timber extraction routes. The forests provided a major source of foreign earning in the post-war periods. In order that the country should enjoy greater added value from its timber raw material, from the beginning of 1979, the export in log form of 14 popular species was halted. A curb on imports denied the forest and timber using industries of vital machinery spares but a recent relaxation now enables exporting companies to convert 20% of their overseas earnings into funding for essential imports. Timber earns about 8% of the country’s foreign exchange being second in importance to cocoa. The combined production figures for the three years 1980–1982 show that of the 1.54M m$^3$ of saw logs, 280,000 m$^3$ were exported; 1.143M m$^3$
of sawn timber, 170,000 m$^3$ were exported and of 162,000 m$^3$ of veneer, 22,000 m$^3$ went abroad. During the same period, over 2.6M T of paper and paper board material was imported. It is planned to establish 4,000 ha of *Gmelina arborea* for a proposed pulp and paper mill. Plantations at present cover 69,080 ha with an annual programme, given help from outside the country, of 11,000 ha.

There has been a dramatic change in climate since the late 1960s with a decrease in rainfall, a reduction in humidity, an increase in temperature and wind speed all contributing to an intense and persistent drought in the north. Wells and rivers have dried, the level of water behind the Volta Dam has been insufficient to maintain full electrical power, bush fires have claimed lives and property and slopes have become denuded. The extension of the Sahel into the country is now becoming a real threat. Erosion control and the maintenance of water supplies both come within the remit of the Forestry Department; the need for protection forests in the drier north is fully appreciated. There is also a national requirement for firewood; wood lots in the North, Upper East and West Departments have established 3,416 ha with *Cassia siamea*, *Azadirachta indica* and *Anogeissus leiocarpus*. A further 3,000 ha of planting of fuelwood is planned in the north during the 1984–86 period. A current education programme is encouraging small farmers to plant trees species for their own benefit. In addition to the advice, free seeds and plants are made available. Private forestry is limited to areas around the gold mines where the plantations are of *Tectona grandis*, *Gmelina arborea* and *Cassia siamea*.

The Forest Policy aims to ensure that the forests provide a sustained yield of timber products for both the local and the export market. There are a known 100 sawmills, 9 plywood, 11 veneer mills and a match factory. The latter has established plantations of *Cedrela* and *Gmelina*. The mills of Mim Timber Co., Gliksten (West Africa Ltd), Takoradi Veneer and Plywood Co., African Timber and Plywood Ltd and Western Timbers are now all State owned. Other materials from the forest which support private and commercial operations include *Oxytenanthera abyssinica* for rattan, *Ancistrophyllum opacum* and other bamboos, *Elaeis guineensis*, *Raphia hookeri* and *Borassus aelhiopum* as a source of food, palm wine and a variety of domestic articles. A firm Messrs Forest Enterprises exports £180,000 worth of forest medicines including seeds of *Griffonia simplicifolia*, and *Voacanga africana*, fruit of * Dioscoreophyllum cumminssii* and *Thaumatococcus daniellii*, frozen pulp of *Synsepalm dulcisicium* and whole plants of *Heliotropium indicum*.

Considerable overseas financial assistance is helping to bring the forest industry back into sustained production. Several International Agencies, UN/FAO, the World Bank, individual countries, the UK, Canada and Cyprus are helping with training and forest education. Some staff of the Forest Service have taken part in courses in Ibadan, Cyprus, Minnnesota, and in the UK at the CFI Oxford, High Wycombe, and Newton Rigg and with the help of the Commonwealth Fund for Technical Co-operation, eight Technical Officers trained at Dehra Dunn. The Forestry Department regrets that during the last three years, 140 staff of the rank of Senior/Forest Guard up to and including three Senior Assistant Conservators of Forests have chosen to employ their talents elsewhere.

**LESOTHO**

The mountainous country, formerly known as Basutoland, with elevations between 1,450 m and 3,431 m is encircled by the Republic of South Africa. The land area is 3,035,500 ha, the estimate of forest area is 10,612 ha, the area of forest reserve is 8,112 ha. There is very little natural forest, such that does remain being inaccessible at the foot of eroding cliffs. Records of tree planting date from 1834 using *Acacia* and *Populus*
canescens giving a plantation area by 1960 of 2,500 ha. By the end of 1984, the plantation area was about 6,920 ha of which 4,421 ha was within the forest reserves. The area under eucalypts is 2,960 ha, mostly Eucalyptus rubida, 1,110 ha is planted with pine, Pinus radiata and P. halepensis and the remaining 351 ha planted with Acacia and poplar, Populus deltoides and P. canescens.

The population is estimated at just under 1.5M. The annual fuelwood consumed by households averages 1.1 to 1.5 T in the drier south and 1.8 to 2.6 T in the north. The weight of coal imported in 1981 was 63,350 T, the volume of fuelwood imported in 1982 was 60,000 m³. The area of plantation which would be required to supply the quantity of fuelwood needed by 2001 is calculated at 130,000 ha. A project of this size would require the joint efforts of the state, private individuals and communities, the state planting of 50,000 ha is considered feasible. The Lesotho Woodlot Project, started in 1973, has so far received funds of £1,320,425 from ODA, £880,300 from the Anglo-American Corporation and De Beers, £102,162 from the Swedish Development Agency and £8,528 from the German Development Bank. The Project will continue until 1987 with the first two sponsors offering, between them, a further £1M.

The forests now occupy 0.27% of the land area, arable land is 6.9%. The remaining mountain and range land is subject to considerable sheet and gully erosion. The establishment of woodlots offers employment, stabilisation of the soil, an improvement in watershed protection and the environment. There is also the prospect of sustained production of forest goods and services and some 8 to 10 years after planting the woods can be opened for grazing, which is then usually better than on the unforested lands. The Swedish Red Cross is encouraging school children to plant trees and appreciate the benefits which the woodland can offer.

MALAYSIA

The total area of peninsular Malaysia, Sarawak and Sabah is about 33M ha. The estimated area of forest has decreased from 21.2M ha in 1979 to 20.6M ha in 1983. The population is approximately 15M; if the current growth rate of over 3% is maintained, the population by 2100 would be over 70M. Each of the 13 Federal States is empowered to enact its own forestry laws but the Federal Government takes care of research, training and technical assistance.

For the purposes of management, the forested area is considered as Dipterocarp, Freshwater Swamp or Mangrove. Of the present 20.57M ha, the proposed area of permanent forest is 13.9M ha of which 4.7M ha will be amenity and protection forest. The relative distribution can be represented for the three land units.

<table>
<thead>
<tr>
<th>Area in '000 ha</th>
<th>Dipterocarp</th>
<th>Swamp</th>
<th>Mangrove</th>
<th>Total</th>
<th>Reserve</th>
<th>Protection</th>
<th>Production</th>
<th>Forest % now</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peninsular</td>
<td>5,974</td>
<td>459</td>
<td>108</td>
<td>6,541</td>
<td>4,800</td>
<td>1,900</td>
<td>2,900</td>
<td>49.7</td>
</tr>
<tr>
<td>Sabah</td>
<td>4,112</td>
<td>167</td>
<td>316</td>
<td>4,605</td>
<td>3,400</td>
<td>400</td>
<td>3,000</td>
<td>62.3</td>
</tr>
<tr>
<td>Sarawak</td>
<td>7,783</td>
<td>1,473</td>
<td>174</td>
<td>9,430</td>
<td>5,700</td>
<td>2,400</td>
<td>3,300</td>
<td>76.5</td>
</tr>
</tbody>
</table>

The respective areas of National Park, Nature Reserve and Wild Life Reserves for the Peninsular, Sabah and Sarawak are 744,766 ha, 386,311 ha and 82,940 ha. In addition, 17,157 ha on the Peninsular are reserved as 'virgin jungle' and a further 667,647 ha of forest is proposed for reservation with priorities other than timber production.

In much of the natural forest, the stocking of young trees of commercial species is sufficiently high to warrant regeneration with a selection system. The plantations which have been established are with conifers such as Pinus caribaea, P. merkusii and Araucaria spp and broadleaves including Gmelina arborea, Eucalyptus camaldulensis, Acacia
mangium and Paraserianthes falcataria. In addition to the planting of timber species such as Tectona grandis and Swietenia macrophylla, there is increased interest in ornamental species for urban areas and in the neighbourhood of villages, forest fruit trees such as Durio zibethinus, Parkia speciosa and species of Pithecellobium and Manifera. On Peninsular Malaysia, the area of plantation established by 1983 was 6,754 ha, by 1985 a further 8,393 should be planted and under the Compensatory Plantation Project it is intended that 188,200 ha should be established by 1995. Finance of £18.8M from the Asian Development Bank is assisting the Project. In Sabah, the State Forest Service had established 16,581 ha by 1983 and proposes to plant a further 100,000 ha by 1998. Private interests had established 24,444 ha by 1983 and envisage planting a further 61,000 ha by 1990.

There has not yet been any large scale planting in Sarawak but research and provenance trials have been planted and some forest invaded by shifting cultivation has been rehabilitated. Although some forest land is being deliberately converted into oil palm and rubber plantation, the area for these two and agriculture being half a million ha between 1981–85, it is the shifting cultivator who poses the major threat to the forest reserve and the potential tree planter.

Wood and wood products are responsible for 6.8% of the GNP of Malaysia, 14.1% of the 1983 export earnings, timber earning £1,548M. The volume of logs felled in 1983 was 32.8M m³. Peninsular Malaysia prohibited the export of logs of 16 species; the list has now increased to 27 species. Malaysia's log exports for 1983 were 18.8M m³, of the sawn timber total of 7.1M m³, 3.4M m³ was exported, of the 687,934 m³ of plywood, 477,913 m³ was exported and of the 598,336 m³ of veneer, 529,802 m³ was exported. The pulpwod production in 1983 was 72,433 T.

The Wood based industries employ 121,500 and the Forestry Departments 9,484. The total volume of timber on trees over 45 cm DBH estimated for Peninsular Maylasia is 578.6M m³. This is a reduction in the volume estimated in 1972 of 35.7%.

Overseas assistance has been received from the USA, Canada, New Zealand, Japan, Finland, Belgium and West Germany, from the UNDP, EEC and in particular from the Asian Development Bank.

MALTA

The total area of the islands is 317 km². It is estimated that 30 km² might be suitable for tree planting. Australia has donated earth moving equipment which is allowing terraces to be constructed for agricultural extension. Associated tree planting is for shelter and soil stabilisation. The species chosen for the more fertile sites include Olea europea, Ceratonia siliqua, Prunus amygdaluscomums, Ficus cariea and Punica granatum. Poorer sites can be established with Pinus halepensis and Cupressus sempervirens. Trees are planted to increase rainfall penetration and to enhance the amenity which supports the valuable tourist trade.

UGANDA

The area of land, and swamp is 20.4M ha. The Forest Estate is 1.53M ha (7.5%) of which 487,443 ha are 'Productive Natural Forest', 245,056 ha are 'Protective Forest', 768,422 ha are 'Savannah Woodland' and 28,000 ha are plantations. The population is 12.6M. The bulk of the existing high forest is gazetted and 768,000 ha of savannah is available for planting. No significant planting has taken place during the last four years. Some of the 25 sawmills have ceased to exist but the plywood mill and the paper mill continue to function. The latter relies upon pulp imported from Scandinavia. There are 2,000
pit sawyers and 3,000 employed in charcoal manufacture. Since 1979, the Technical Staff has increased from 382 to 447 and the Professional Staff from 69 to 152. Roundwood consumption has risen from 51,000 m³ to 77,000 m³. The volume of timber used annually as poles is 1.0M m³ and for fuelwood 14.3M m³. The source of commercial energy depends directly upon wood for 53% with an additional 14.2% from charcoal. Taking the whole of the country into account, wood supplies 96% of the energy requirement. Industries which rely upon wood for fuel or for various processes include tobacco, tea, sugar/jaggery, fish smoking, clay conversion for bricks, tiles and pottery. The price of electricity rose between November and December 1984 by 220%.

The forestry aspects which suffered during the military regime resulted from deliberate flouting of forest laws, with farmland encroaching over 3% of reserve area and from the neglect of regeneration, of the thinning of established pine plantations and the upkeep of records and working plans. The liberation war in 1979 destroyed most of the buildings of the Forestry College. Help in training and forest education is coming from the UK, New Zealand, Australia, Cyprus and through FAO, UNDP, NORAD, ICRAF and the World Bank. CARE (Co-operation for American Relief Everywhere) is spending $731,279 on social forestry in the west, FAO/Swedish Trust Fund has a $53,000 rural household tree planting scheme in the east and centre and ODA is funding £150,000 for forest inventory in the west.

UNITED KINGDOM

The Broadleaved Woodland Grant Scheme will apply at the following rates from 1 October 1985.

<table>
<thead>
<tr>
<th>Area in ha</th>
<th>Planting yrl</th>
<th>yr 6</th>
<th>yr 11</th>
<th>Natural Regen. yrl</th>
<th>when stocked</th>
<th>+ 5 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25–0.9</td>
<td>£840/ha</td>
<td>180</td>
<td>180</td>
<td>600</td>
<td>360</td>
<td>240</td>
</tr>
<tr>
<td>1.0–2.9</td>
<td>700</td>
<td>150</td>
<td>150</td>
<td>500</td>
<td>300</td>
<td>200</td>
</tr>
<tr>
<td>3.0–9.9</td>
<td>560</td>
<td>120</td>
<td>120</td>
<td>400</td>
<td>240</td>
<td>160</td>
</tr>
<tr>
<td>10.0 plus</td>
<td>420</td>
<td>90</td>
<td>90</td>
<td>300</td>
<td>180</td>
<td>120</td>
</tr>
</tbody>
</table>

Forestry Grant Scheme: 1 October 1985

<table>
<thead>
<tr>
<th>Area in ha of wood</th>
<th>Conifers</th>
<th>Broadleaves</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25–0.9</td>
<td>£630/ha</td>
<td>890</td>
</tr>
<tr>
<td>1.0–2.9</td>
<td>505</td>
<td>735</td>
</tr>
<tr>
<td>3.0–9.9</td>
<td>420</td>
<td>630</td>
</tr>
<tr>
<td>10.0 plus</td>
<td>240</td>
<td>470</td>
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</table>

Basis 11 and 111 Dedication Schemes: 1 October 1985

<table>
<thead>
<tr>
<th>Planting Grant: Basis 11</th>
<th>£110/ha</th>
<th>Basis 111</th>
<th>Conifers £145/ha</th>
<th>Broadleaves £330/ha</th>
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<tbody>
<tr>
<td>Management Grant &lt; 40 ha</td>
<td>£4.80</td>
<td></td>
<td>£4.20</td>
<td></td>
</tr>
<tr>
<td>Areas &gt; 40 ha &lt; 80 ha</td>
<td>£3.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>balance &gt; 80 ha</td>
<td>£2.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Please see also, the address to the 1985 AGM)

VANUATU

The islands of the New Hebrides gained independence in 1980. Their area is 1,219,000 ha of which 900,000 to 1M ha is ‘forest’. Much of the ‘forest’ is secondary, being post-cultivation or post-hurricane. There is some Tropical High Forest with merchantable
species providing 50 m$^3$/ha. The group of young volcanic islands lies to the east of the Coral Sea, between Northern Australia and Fiji, the population is 127,800. In addition to the 350 ha of plantation established by 1979, a further 1,550 ha has been planted by the end of 1984. Planting has been carried out on 14 islands with broad leaved species such as *Cordia alliodora*, *Eucalyptus deglupta* and *E. urophylla* and on the drier area in the rain shadow of the high ground with pine, *Pinus caribaea*. Most of the 400 ha of the latter is on Aneityum and on Erromango. It is intended that the pine will form the basis of industrial and commercial operations. The current 200 ha annual programme of establishment will increase to 1,100 ha in 1986. Log exports of indigenous timbers are now banned, apart from logs of *Antiaris toxicaria*. The 1983 figures show that 4,030 m$^3$ of veneer logs were exported, 7,987 m$^3$ of saw logs were converted locally with 634 m$^3$ of 3,395 m$^3$ of sawn timber and sleepers being exported. The annual cut of about 12,000 m$^3$ is expected to drop slightly until the plantation produce becomes available.

The government levies a tax when trees are felled. Half of this is passed to the local owners of the trees, half of the balance can be returned as a rebate if the logs are converted locally; the remainder contributes to the cost of replanting. Owners and communities are encouraged to become involved with tree planting for their own uses. They retain the land on which the trees are planted, the government pays for the plants, the materials and labour but will recoup these costs — free of interest — when the crop is harvested. The forestry work gives a worthwhile source of employment, the promise of future raw materials which will offer an alternative to the present reliance on the export of copra. There is also some control on vegetation which might otherwise degenerate into climber tangles or areas of grass with its attendant risk of fire. Up to 200 ha of this ‘local supply’ tree establishment is being encouraged annually. It is possible for some farm crops to be planted with the trees: a species such as *Cordia alliodora* can tolerate the introduction of cattle into a four year old crop. They will leave the trees alone and eat the climbers and other weeds.

There is at present no shortage of fuelwood. The possibility is being considered of installing a 3 megawatt wood fuelled power station for Port Vila but if this eventuates, appropriate plantations will be established for its requirements.

**ZIMBABWE**

The total land and water area of Zimbabwe is 39,075,900 ha. The area covered by indigenous forest and savannah woodland with at least 10% of ground cover, is 23,094,320 ha. State owned indigenous forest area is 744,320 ha. The main commercial indigenous species is Zambesi teak, *Baikiaea plurijuga* with *Pterocarpus angolensis* also being important. The annual export earnings from indigenous wood is just under £2M. Communal lands cover 42% of the country and accommodate 59% of the population, approximately 8M. The 1983 estimate of fuelwood collected free from these communal lands is 3.8M m$^3$, about 56% of the country's total wood production.

The Forestry Commission started planting in the 1920s and the State plantations now cover 27,951 ha. The annual planting rate of about 440 ha prior to independence has increased to 1,000 ha between 1980 and 1985. State planting is 66% with pine, mainly *Pinus patula*, 18% with eucalypts and 15% with wattle. Private commercial plantations cover 71,806 ha, non-commercial farm woodlots on 11,053 ha are 94% eucalypts and a further 4,500 ha of communal plantations brings the June 1984 total to 115,310 ha of tree plantations. During 1984/85, some 150 ha of trial plantations have been set out with species which might perform in semi-arid conditions. Many Australian species are being assessed.
The 1983 summary of home grown wood consumption, totals almost 6.8M m$^3$. Industrial wood is just under 0.5M m$^3$, roughly 90% exotic, 80% conifer. Fuelwood used just over 5M m$^3$, only 4% being of plantation origin. The two other main uses for wood were for poles and for tobacco curing, 1.22M m$^3$ with over 1M m$^3$ coming from indigenous timber. The country is self-sufficient in sawn softwood, a saving in imports of about £15M a year. There is a surplus of small conifer which would be suitable for pulp. Pulp and paper imports cost about £12M a year. The Canadian International Development Agency is assessing the feasibility of a pulp mill.

Since independence the Forestry Commission has increased minimum felling diameters and increased the length of felling cycles. There is increasing pressure from agriculture and grazing on the remaining 23M ha of ‘forest’. The annual production of 5.9M m$^3$ from this area is less than 0.5 m$^3$/ha whereas the 814,205 m$^3$ from the 115,310 ha of plantation is over 7 m$^3$/ha. There is little land still available for commercial afforestation but the State did acquire 17,868 ha in 1983/84, half of which will be suitable for planting. The main hope for keeping some of the indigenous woodland will be if communal land planting can be encouraged. Funds from the World Bank are making a major contribution to the social forestry planting. Some £3.6M is available over the 5 year period to 1987. Help is also coming from Australia, Canada, Denmark, Finland, the USA, the UK and from the United Nations.

The Forestry Commission is now able to operate commercially. The first Commission sawmill started in 1982 and during the last five years, the logging and milling operations have brought in £1.5M. Revenue is also collected from safari expeditions and staff are made aware of the value of the wildlife. There are now 28 professional officers, compared with 14 in 1979, staff has increased by 1,000 to 2,947. Private forestry employs 7,500 skilled and semi-skilled workers and 394 in management whilst the ancillary wood and paper industries employ a further 7,000.
Twelfth Commonwealth Forestry Conference  
Victoria, British Columbia, September 8 to 22, 1985

Programme

"INVESTMENT IN FORESTRY—
THE NEEDS AND OPPORTUNITIES"

The Conference will discuss what needs to be done to secure the many and diverse social, economic and environmental benefits of forestry by well planned investment, using available land, labour, skills and scientific research.

Honorary Presidents

The Honourable Gerald S. Merrithew, Minister of State (Forestry)  
The Honourable Thomas M. Waterland, Minister of Forests, Province of British Columbia

SUNDAY, 8 SEPTEMBER

15:00 Conference registration desk open (lower floor, Empress Hotel)  
Conference office open (Duke of Kent Room, Empress Hotel)  
Tea (Georgian Room, Empress Hotel)  
19:00 Reception (Georgian Room, Empress Hotel)

MONDAY, 9 SEPTEMBER

09:00 Opening Ceremonies (Newcombe Auditorium, Provincial Museum)  
Chairman—The Honourable Gerald S. Merrithew, Minister of State (Forestry)  
Rapporteur—Mr. S. Glover, Scientific Editor, Canadian Forestry Service  
Official opening: His Honour, The Honourable Robert G. Rogers, Lieutenant-Governor of British Columbia

09:25 Welcome from the Government of Canada: The Honourable Gerald S. Merrithew, Minister of State (Forestry), Canada

09:45 Welcome from the Province of British Columbia; The Honourable Thomas M. Waterland, Minister of Forests, Province of British Columbia

10:05 Welcome from the City of Victoria: His Worship Mayor Peter Pollen, City of Victoria

10:45 Opening address: Sir Peter Marshall, KCMG, Deputy Commonwealth Secretary-General (Economic)

11:30 Address on the theme of the Conference: The Honourable Donald S. Macdonald, Chairman Royal Commission on the economic union and development prospects for Canada
SESSION 3: CONFERENCE CONTINUITY, ELECTIONS, PROCEDURES AND COUNTRY REPORTS

Chairman—Mr. George Holmes, Chairman of the Standing Committee on Commonwealth Forestry. Rapporteur—Mr. S. Glover, Scientific Editor, Canadian Forestry Service

14:10 Election of Conference and Session Chairmen
14:25 Conference procedures and rules
14:35 Recommendations of the Eleventh Commonwealth Forestry Conference, Trinidad and Tobago 1980, Mr. George Holmes.

15:20 Country progress reports summarized by region
15:30 Asian Region. Rapporteur—Dr. G. S. Nagle, President, Nawitka Resource Consultants Ltd.
16:30 Australasian Region. Rapporteur—Mr. E. H. Hindley, Manager Asian Operations, Reed Collins and Associates Ltd.

TUESDAY, 10 SEPTEMBER

09:00 European Region. (Newcombe Auditorium) Rapporteur—Dr J. V. Thirgood, Faculty of Forestry, University of British Columbia
10:30 Africa—South Equatorial Region. Rapporteur—Dr. R. M. Strang, Executive Director, Secretariat on Forestry Research & Development, Forest Research Council (Province of British Columbia)
11:30 Africa—North Equatorial Region. Rapporteur—Mr. R. W. Roberts, Chief, Forestry Sector, Canadian International Development Agency
14:00 Group Photograph
14:15 Pacific Islands Region. Rapporteur—Mr. J. Dosne, Consultant, World Bank
15:45 Caribbean Region. Rapporteur—Mr. C. Clarke, International Relations Officer, Canadian Forestry Service
16:45 North American Region. Rapporteur—Dr. R. J. Bourchier, Executive Director, Canadian Institute of Forestry

Evening Edinburgh forestry alumni reunion (Holyrood House, 2315 Blanshard St., Victoria)

WEDNESDAY, 11 SEPTEMBER

SESSION 4: INVESTMENT IN FORESTRY THE NEEDS AND OPPORTUNITIES

09:00 ‘The Challenge—the case for investment in forestry’ (Newcombe Auditorium) Rapporteur—M. B. W. McCloy, Manager Environment and Forest Management, Council of Forest Industries of British Columbia
Theme Address: Mr. J. S. Spears, Forestry, Advisor, World Bank

10:30 Theme Papers:
   i. Forests for people—the developing country case. Mr. J. E. M. Arnold, Chief of Policy and Planning Service, Forestry Department, FAO/Mr. E. M. Mnzava, Director of Forestry. Forest Division, Ministry of Lands, Natural Resources and Tourism, Tanzania.
   11:30 ii. Forests for people—the developed country case. Dr. S. W. Gentle, Commissioner, Forestry Commission of New South Wales, Australia
14:00 iii. Forests for environmental protection and improvement. Dr. T. N. Koshoo, Secretary to the Government of India, Department of Environment, India
15:00 iv. Forests for Energy. Dr. N. P. Overend, Renewable Energy Task Coordinator, National Research Council, Canada
CONFERENCE PROGRAMME

17.00 Reception. Hosted by His Honour, R. G. Rogers, Lieutenant-Governor of British Columbia, and Mrs. Rogers
(Assembly point is the Georgian Room of the Empress Hotel where bus transportation will be provided to Government House)

THURSDAY, 12 SEPTEMBER

09:00 Session 4. A. cont’d. Dr. D. Haley, Professor, Forest Economics, Department of Forest Resources Management, University of British Columbia
v. Forests for industry. Mr. B. Downey, Chief Executive and Managing Director, Marac Holdings, New Zealand
10:30 vi. Investment in processing in developed countries. Mr. G. J. Francis, Commissioner, Operations, British Forestry Commission, UK.
11:30 vii. Investment in processing in developing countries. Mr. G. Gresham, Secretary, Forest Industries Council of Papua New Guinea, Papua New Guinea
14:00 viii. Forestry research. Dr. Salleh Mohd Nor, Director, Forest Research Institute, Malaysia, and Dr. J. Burley, Director, Commonwealth Forestry Institute, UK.
15:30 ix. Investment requirements for education and training, Dr. R. V. Singh, President, Forest Research Institute and Colleges, India
16:30 x. Developing the economic arguments for investment in forestry. Mr. D. S. Grundy, Head of Planning and Economics, British Forestry Commission, UK.
20:30 Canadian Films (Newcombe Auditorium)

FRIDAY, 13 SEPTEMBER

Day tours
07:15 Day tour buses begin loading at the south entrance of the Empress Hotel. Day Tour numbers identify the respective buses.
07:30 All tours leave the Hotel: No 1: Forest Research Establishments—Federal and provincial research laboratories (Red Ticket). No. 2: Demonstration Forests—silvicultural treatments, fertilization, spacing, etc. (Blue Ticket). No. 3: Forest Industry Operations—logging and sawmilling (Green Ticket). No. 4: Seedling Production and Tree Improvement—nurseries and seed orchards (Yellow Ticket).
18:00 Logger Sports—Salmon barbecue (Community Hall, Sooke)
23:00 Buses return to the Empress Hotel

SATURDAY, 14 SEPTEMBER

09:00 Session 4. B. ‘Financing forestry’ (Newcombe Auditorium) Rapporteur—Dr. E. A. F. Wetton, Forestry Consultant, Victoria, British Columbia.
09:30 Theme address: Mr. B. I. Howe, President and Chief Executive Officer, British Columbia Resources Investment Corporation, Canada.
10:30 i. Finance from the international agencies. Mr. B. N. Ganguli, Senior Forestry Specialist, Asian Development Bank, and Mr. W. B. Otieno-Obura, Agricultural Economist, Africa Development Bank
11:30 ii. Mobilizing private sector investments—the developing world. Dr. C. Chandrasekharan, Senior Forestry Planning Officer, FAO.
14:00 iii. Mobilizing private sector investments—the developed world. Mr. J. Puusepp, Associate Vice-President and Forest Products Analyst, Pemberton Houston Willoughby Inc., Canada.

16:30 v. Success stories
   a. Commercial plantation forestry in Fiji, the Fiji Pine Commission Case. Mr. P. J. Drysdale, General Manager, Fiji Pine Commission, Fiji.

17:30 Adjourn

SUNDAY, 15 SEPTEMBER
   Free Day

MONDAY, 16 SEPTEMBER

   Theme address: Mr. P. M. South, Director, Woods and Forests Department, South Australia.

10:30 Theme papers
   i. Allocation of land for forestry, Mr. T. M. Apsey, Council of Forest Industries of British Columbia, Canada.
   ii. Institutional obstacles to the effective use of resources. Dr. F. Owino, Chairman, Department of Forestry, University of Nairobi, Kenya.

12:30 Bus transportation to the Pacific Forestry Centre leaves the Newcombe Auditorium.

12:50 Tree planting ceremony to commemorate Twelfth Commonwealth Forestry Conference during the International Year of the Forest. Official opening of the building addition at the Pacific Forestry Centre, 506 West Burnside Road, Victoria.

13:30 Lunch. A light lunch will be provided at the P.F.C. cafeteria.

14:10 Buses leave for the Newcombe Auditorium.

14:30 iii. Getting technical information to the field manager. Mr. W. Finlayson, Director, Commonwealth Forestry Bureau, UK.

16:00 iv. Data needs and recent developments in resource planning and management. Mr. A. Kirkland, Director General of Forests, New Zealand Forest Service, New Zealand.

19:00 No host bar (Tea Room, Empress Hotel)

20:00 Canadian Government Banquet. Hosted by The Honourable Gerald Merrithew, Minister of State (Forestry), Canada (Crystal Ballroom, Empress Hotel)

TUESDAY, 17 SEPTEMBER

09:00 Session 4. C. continued. (Newcombe Auditorium)

v. Opportunities for increasing the scope and efficiency of forest planning through high technology. Mr. F. Hegyi, Director, Planning and Inventory Branch, Ministry of Forests, Province of British Columbia, Canada.
10:30 vi. Protecting the investment. Dr. G. L. Baskerville, *Dean of Forestry, University of New Brunswick, Canada*

11:30 vii. National policies for investment in temperate forestry. Mr. F. L. C. Reed, *Research Professor, Forest Policy, University of British Columbia, Canada*


15:45 Tour of the Planning and Inventory Branch, British Columbia Ministry of Forests, 1319 Government Street, Victoria. Demonstration of an integrated computer-assisted mapping and satellite image analysis system used in provincial forest planning and management

20:30 Canadian Films (Newcombe Auditorium)

**WEDNESDAY, 18 SEPTEMBER**

**09:00 SESSION 5: GROUP DISCUSSIONS** (Newcombe Auditorium)

Rapporteur — Dr. R. M. Strang, *Executive Director, Secretariat on Forestry Research & Development. Forest Research Council (Province of British Columbia)*

This day will be available for discussion of topics raised by participants. Group leaders will be selected and meeting rooms assigned on Monday September 16

14:00 Afternoon free for committee meetings and informal gatherings

16:30 Reception Hosted by Wajax Manufacturing Limited (Prince of Wales Room, Empress Hotel). (A chance to meet one of our advertisers. See Front Cover.)

18:00 **Meeting of the Commonwealth Forestry Association** (Prince Albert Room, Empress Hotel)

**THURSDAY, 19 SEPTEMBER**

**09:00 SESSION 6: COMMONWEALTH CO-OPERATION** (Newcombe Auditorium)

Rapporteur — Dr. J. Harris, *Research Scientist, Entomology, Pacific Forestry Centre, Canadian Forestry Service*

09:40 A. Reports of Commonwealth Agencies

i. Commonwealth Secretariat. Prof. J. I. Furtado, *Science Advisor, Commonwealth Science Council*

ii. Commonwealth Forestry Institute. Dr. J. Burley, *Director*

11:00 iii. Commonwealth Forestry Bureau. Mr. W. Finlayson, *Director*

11:40 iv. Commonwealth Development Corporation. Mr. A. C. Finch, *Senior Forester*

13:45 v. Commonwealth Forestry Association. Mr. M. T. Rogers, *Editor & Secretary*

14:15 **Co-ordination of bilateral aid in the Commonwealth.** Mr. R. H. Kemp, *Forestry Advisor, Overseas Development Administration UK*

15:45 What needs to be done to increase Commonwealth co-operation and to increase the benefits from co-operation. Summary by session chairman

20:00 Reception for Commonwealth Forestry Association members and friends (Oak Bay Beach Hotel)

**FRIDAY, 20 SEPTEMBER**

**SESSION 7: CONCLUSIONS** (Newcombe Auditorium)

Rapporteur — Dr. A. Van Sickle, *Head, Forest Insect and Disease Survey, Pacific Forestry Centre, Canadian Forestry Service*

09:00 Presentation and discussion of reports by the session chairmen
10:30  Session reports continued
14:00  The way ahead. Dr. P. H. Pearse, Project Leader, Forest Economics and Policy Analysis Project, University of British Columbia, Canada
16:30  C. Selection of the location and date of the Thirteenth Commonwealth Forestry Conference
19:00  No host bar (Tea Room, Empress Hotel)
20:00  Province of British Columbia Banquet. Hosted by the Honourable Thomas M. Waterland. Minister of Forests, Province of British Columbia (Crystal Ballroom, Empress Hotel)

SATURDAY, 21 SEPTEMBER
Session 7 continued. (Newcombe Auditorium) Rapporteur—Dr. A. Van Sickle, Head, Forest insect and Disease Survey, Pacific Forestry Centre, Canadian Forestry Service
09:00  Adoption of recommendations
11:00  Approval of press release
12:00  Standing Committee on Commonwealth Forestry
12:30  Outline of plans, including location and date, for the Thirteenth Commonwealth Forestry Conference
13:05  Tour briefing: for those participating in the post-conference tour of Southern Vancouver Island (Newcombe Auditorium)

MONDAY, 23 SEPTEMBER
07:15  Post-Conference Tour of Southern Vancouver Island (south entrance of the Empress Hotel)
07:30  Buses leave the Empress Hotel

TUESDAY, 24 SEPTEMBER
Post Conference Tour continues

WEDNESDAY, 25 SEPTEMBER
19:00  Buses return to the Empress Hotel. Post Conference tour terminates.
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Forests, Trees and People

In developing as well as developed countries, forests provide the raw materials for a range of important industries whose products are widely used in the modern sector of the economy. In addition, forests perform an essential role in maintaining environmental stability. In developing countries, forests and forest trees also contribute in a wealth of other ways to the daily life of people in their immediate vicinity. This paper is concerned primarily with the last of these contributions — the direct dependence of people in developing countries on forests and the outputs of forests.

More than 70% of the total population of the developing world lives in rural areas. This percentage is much higher in individual countries, such as Tanzania where it is 87%. Despite increasing migration to urban areas, the rural population of the developing world is rising and is likely to continue to do so for at least the next few decades.

Most of these rural people rely on locally available forests and trees for supplies of fuel and other essential goods and services for which, because of their poverty, there are no effective commercial alternatives. Many of them continue to live in the forest, and depend upon it to sustain life itself. At the same time forest products provide the basis for much rural employment and income. In one way or another forests and forest products are important to most of the rural people of the developing world, as is indicated by the following listing of the more important contributions of forests and forestry:

- Some 2,000 million people — the poorer half of mankind — depend on wood for cooking their food; fuelwood shortages have rightly been described as the energy crisis of the poor.
- As many as 500 million people depend upon forms of shifting cultivation within the forest to produce the food they need; on tropical soils which can support crop production only through the nutrient-restoring presence of trees during part of the production cycle.
- Much larger numbers live in situations in which their soil and water resource base is deteriorating because of the direct or indirect effects of excessive removal of trees; resulting in declining soil productivity, erosion, flooding, siltation, etc.
- Forests directly produce a wide range of foods which provide nutritionally valuable supplements to diets based on one or a few staples.
- Harvesting, processing and marketing of forest products create one of the largest sources of rural employment and income other than farming; increasingly important as the numbers grow of rural people who are landless or who have too little land to be able to support themselves from farming alone.

The importance of these links between forests and people is not confined just to their value to the individuals, families and communities directly concerned, critical though these values often are. These outputs of the forest also play a significant role in the overall development process, through their contributions to rural development.
Thinking about how economic development occurs, and how to stimulate it, has changed considerably over the years. Though there were notable exceptions to the general trend, during the 1950s and 60s the focus tended to be on achieving development through growth of the ‘modern’ industrial/urban sector, and through trade-led programmes which would earn or save foreign exchange. It was argued that the added wealth created in this way would in due course spread to the rest of the population living in the ‘traditional’ rural sector through a ‘trickle down’ process.

During the 1970s, development theory underwent a radical change. Industrial and trade-led growth strategies patently were not working in most countries, and even where they were there was little diffusion of the wealth to the rural population. Furthermore, it had become increasingly apparent that by relegating the rural sector to this essentially passive role in the development process, countries were neglecting one of their most important assets — the human resources of the greater part of the population.

The sharp shift in development strategies towards giving priority towards rural development was designed to mobilise the interests and energies of rural populations. It was based on the recognition that to do so, development programmes must concentrate on removing or at least lessening the burdens of acute poverty which constitute the principal constraint which most rural people in developing countries face in trying to improve their conditions. The thrust of this new approach to development was well expressed by President Nyerere of Tanzania, at the World Conference on Agrarian Reform and Rural Development in 1979, when he stated ‘A policy of rural development is a policy of national development. You cannot have rural development as an extra, tagged on to the other policies of Government . . . Rural development must be a description of the whole strategy of growth . . .’

Rural development remains the principal focus of most countries’ development strategies, to which current strategies for the forest sector need to respond and contribute. During the last few years these broader strategies have unavoidably had to be modified by pressures arising from the lengthy period of depressed world activity. The huge debt burdens that so many countries have incurred, in a period of sharply higher costs of importing oil and other necessities and of reduced export prospects, have forced them to give priority to self-sufficiency in the necessities of life, notably food. At the same time, the reduced availability of aid from many sources has forced many countries to give a lower priority to measures other than meeting the most immediate needs. The result has been to slow down some of the longer term changes needed in order to pursue rural development.

This, then, is the context within which most developing countries find themselves at present, and which determines their priorities for the forest sector. Though it would be unwise to generalise too freely, it appears that quite widely governments presently attach particular importance to the part that forestry can play in maintaining the soil and water resource base for food and agricultural production. From among those needs that people try to meet from forests and trees, high priority tends to be attached to those which contribute directly to increased food self-sufficiency, or which need action in order to avoid or reverse excessive deforestation which would cause further environmental damage to the resource base.
CASE FOR INVESTMENT OR CHALLENGE TO INVEST?

By S. W. GENTLE
Forestry Commission of NSW Australia

The Conference Theme

This Twelfth Conference has a very positive theme: Investment in Forestry. Our Session invites Challenge, this thematic strand addressing the specific subject, Forests for People. There is perhaps nothing so positively challenging to people anywhere as the depleted bank account which immediately follows investment — the transfer of funds to make that investment — the hollow feeling when one asks: was it worth it? Nor is there a more positive challenge than making the investment for people in the plurality that is encompassed by that term at our Conference. We are invited to explore means to seeing that such investments are made.

This paper stresses challenge as the issue: increasingly, the case for forest investment in developed countries must surmount challenge. At this point foresters often divide into pessimists and optimists about our chances. This paper takes the optimistic view.

INVESTMENT IN RESEARCH

By DR J. BURLEY
Head of the Department of Forestry, Oxford University, CFI Oxford, England
and DR M. SALLEH NOR
Director, Forest Research Institute, Kepong, Kuala Lumpur, Malaysia

There is a continuum from research through development to application and researchers should be aware of, and often involved in, all stages of the process of innovation. Research may be classified in many ways with the most common distinction being between science (basic or fundamental research) and technology (applied research). Systems are required for prioritisation of forestry research. Topics and research undertaken should yield reliable, repeatable, unbiased results with biological, economic or managerial value.

Research, like other enterprises, requires land, labour and capital. Secure land for facilities and in-forest, on-station or on-farm research; appropriately trained professional, technical and unskilled staff with secure, rewarding careers; capital in soft and hard currencies, in time for the period of expenditure, to provide appropriate facilities, personnel and equipment. In addition research needs an adequate resource of published and unpublished relevant information; many systems of providing this exist from hard copy abstracts through microfiche to on-line computerised retrieval systems.

All of these requirements cost money and a questionnaire was circulated to all Commonwealth countries and to some donor agencies to determine levels of research expenditure. Of some 22 countries responding, 14 conduct research at costs that vary with many factors. Annual costs range from $4,000 to $80 million. Among 13 countries
the average proportion of research costs to total costs are 12% for forestry and 3% for forest products, giving an overall figure of 7%; this compares favourably with research costs in other industries. Expenditure on forest products is low, especially in relation to the pressing need for better management and use of tropical forests and secondary species.

The few donor agencies surveyed do not always separate research from operational costs, nor forestry from all other natural resources, but clearly they expend large and increasing amounts on forestry assistance approximating £400 million annually.

The planning and programming of research varies between countries, between heads of forest departments, heads of research, and committees of foresters, non-foresters, or both. Few countries or organisations are taking advantage of twinning between institutions to share limited resources and experiences. The International Union of Forestry Research Organisations has established a special Programme for Developing Countries, with financial support from several donors, to encourage local participation in prioritisation of research, twinning of institutions, and participation of scientists in IUFRO’s global research activities.

2B(ii)

MOBILIZING PRIVATE SECTOR INVESTMENTS — THE DEVELOPED WORLD
by J. PUUSEPP of Pemberton Houston Willoughby Inc. Canada

The purpose of this paper is to examine how private sector investment can be mobilized to finance forestry in the developed world. Perhaps a more appropriate title would be “Mobilizing Private Sector Investment in Canada.” My parochial view of the developed world is necessitated by familiarity and ready access of pertinent data.

For many years I have felt that a comprehensive review of forestry and the forest products industry should begin with a study of its capital needs. In order to perform this task objectively, I propose to deal with facts and not general pronouncements of hopes and wishes. After dealing with the facts I hope you will share my alarm at the financial state of the Canadian forest industry. If we are to mobilize private sector investment in this industry, then we are going to have to radically change the way we are currently conducting our affairs. I, therefore, welcome the opportunity to present my views to this distinguished audience.

I will begin by examining the major trends which have shaped the financial statements in the Canadian forest industry, examine investment returns and draw some conclusions as to the significance of these trends for providing capital to the industry over the balance of this decade. Finally, I will focus on possible solutions and future opportunities facing Canada’s forest products industry.

2B(v)

THE ROLE OF THE AFRICAN DEVELOPMENT BANK
by W. B. O. OBURA, Agro-Economist with the ADB.

Until recently, very few people realised just how important a role forests play in our lives, and how devastating the consequences would be to our climates and economics if the current indiscriminate deforestation is allowed to continue unchecked. Trees have remained an important resource in African countries and is an important factor in our social and economic advancement.
Notwithstanding the above situation, deforestation has become a cancer from the global point of view. Deforestation in tropical Africa has been running at about 1.3 million hectares net, per annum. According to the fuelwood surveys conducted by FAO in 1983, it was estimated that annually 3.8 million hectares has been cleared compared to an average of 130,000 hectares of plantings per annum.

High population growth rate in Africa, averaging 2.8% has led to increased demand for agricultural land, shelter, services and energy requirements. The high population growth rate has put heavy strain on Governments’ resources as they endeavour to meet some of the basic requirements of the population. Some countries have intensified logging for export purposes, in order to enable them to earn foreign exchange which could be used to purchase basic goods and services, for development purposes.

It is estimated that at the current rate of deforestation in certain African countries, Senegal will be bare of trees in thirty years time, Ethiopia in twenty and Burundi in seven years time. The destruction of forest cover in Ethiopia, throughout the centuries is playing a very important role in current drought and famine in the country. Also it is believed that the recent increase in intensity of the West African “Harmattan” wind is attributed to deforestation and removal of vegetation cover in the northern part of Africa.

The Bank Group is aware of the economic, social and environmental impact caused by the continued deforestation and desertification. And that effect, the Bank has committed a total of £44 million for implementation of forestry or forestry related projects, and has allocated another £104 to finance such projects within the next 3 or 4 years.

2.B.v

THE ROLE OF THE STATE
IN THE REGULATION OF YIELD FROM PRIVATE FORESTS

By S. D. RICHARDSON
New Zealand Forestry Council, Wellington, New Zealand

Under the Act, a prime function of the NZ Forestry Council is to ‘undertake and enable’ integrative forestry sector planning. Even if restricted to indicative, rather than prescriptive, planning, this task requires that the role of the State in influencing private land management practices (and thus controlling yields) be addressed. The State controls some 54% of the net productive stocked exotic forest area and nearly 75% of the nation’s indigenous forest. Some 80% of the wood marketed annually derives from State forests; even by 1995 — assuming no change in land holdings — the State will dominate supply. To a large extent, therefore, what the State decides determines what the sector does. Moreover, planning in forestry demands a time horizon equal to at least one rotation (for sawlogs, some 25 years). It is desirable that such long-term planning be undertaken in concert between private and public sectors.

In countries in which forest production contributes significantly to the economy — as in Scandinavia and Western Europe — Government controls over forest harvesting on private land are long established. The situation of tight wood supply which will characterise the New Zealand economy over the next few years may warrant closer co-ordination of production here. Controls, it might be argued, should apply to both indigenous and exotic forests.
To provide a background to objective discussion, this working paper outlines for a number of different countries (and economies) the ways in which State control of yield from private forests may be exercised. The selection of countries is to some extent arbitrary and determined by the availability of information. Though the forest laws of the centrally planned economies of Eastern Europe and the People's Republic of China have been published in summary form it is not considered that they provide useful precedents for New Zealand. Nonetheless, the countries treated, cover a range of political and economic variants which exemplify the multiple roles of forestry; and the grouping of countries relates to this variety of roles. Thus, France, West Germany and Austria are characteristic of the 'traditional' forest economies, where multiple social and economic roles of forestry have been recognised and accepted for centuries: where forestry is no Johnny-Come-Lately which must justify each and every claim to a share in land-use. In the United Kingdom and Japan, the roles of forestry are primarily protective and environmental; the forests were much depleted during the 1940s and, because of intense population pressures, the economic role of production forests is no longer dominant or, even, important. In the countries of the third group — Finland and Canada (British Columbia) — production forests provide a mainstay to the economy and criteria governing forest management are distinctive.

Finally, in the United States (California) forestry is significant for both production and environmental impact. Controls — perhaps as a consequence — are more rigid than in any country discussed in this paper.


by A. C. FINCH, CDC, London, England

Commonwealth Development Corporation (CDC) operates in the Commonwealth countries that achieved independence since 1948, dependent territories, and with Ministerial approval in any other developing country. Projects are selected on the basis of their development value to the country concerned and their financial viability. Natural resources projects are given preference during the identification of new investments and the allocation of funds by CDC. Its current policy aims to encourage, and where possible, to increase CDC involvement in forestry and forest industry.

Over the period 1949–1979 the CDC assisted eight industrial forest plantation projects in seven countries, of which one is outside the Commonwealth. The associated primary forest industry that is based on these plantations includes 180,000 tonnes per year (tpy) unbleached kraft pulpmill in Swaziland, 7,000 tpy wattle extract plant in Tanzania, sawmilling in Jamaica, Fiji, Zambia and Tanzania, and a 60 tpy eucalyptus oil extraction plant in Swaziland.

The impetus on plantation investment by CDC slackened between 1980 and 1984 to one major 20,000 ha hardwood project extension in the Ivory Coast. There was, in addition, some self-financed reforestation development by three CDC companies in Swaziland and Tanzania. The most significant new forestry commitments of this period occurred in Tanzania: its financial participation in a 60,000 tpy integrated chemical pulp and paper mill and in a separate 9,000 tpy pulp and paper board mill.

CDC invested £18.1M in the forestry sub-sector between 1980 and 1984; its commitments at 31st December 1984 totalled £35.6M; altogether ca 9,955 people are employed in CDC supported forestry projects, which managed ca 217,000 ha of
3.C. Theme

MAKING THE BEST USE OF INVESTMENT RESOURCES

By P. M. SOUTH
Director, Woods and Forests Department, South Australia

International gatherings of foresters in recent years have concentrated somewhat on forestry's potential to improve the quality of life of humankind, particularly the populations of post-colonial and other lesser-developed countries.

Philosophical concepts which have been advanced with increasing vigour are:
- forests provide a base from which to launch attacks on economic under-development;
- providing they are well planned, investments in forests can be justified because of their manifold socio-economic and other benefits, in almost any circumstance.

Clearly these propositions have their own validity and it is tempting to allow them to outweigh other more practical considerations which, on the surface at least, may seem less altruistic.

However, it seems to be that if an investment in forestry is made for no other reason than that land is available, it is likely that the return on funds would be less than optimal, and inefficient in the use of the investment resource.

The evidence is that the more successful forestry project is characterised by the clear definition of the investor's objectives and the objectivity of its pre-planning.

Where this occurs, the achievement of a successful crop is not seen in every case as an end in itself: very often the ultimate objective is its profitable utilisation by a forest owner, integrated to the maximum extent and aimed primarily at ensuring such a return on funds as would encourage further investment.

3C(iii)

GETTING TECHNICAL INFORMATION TO THE FIELD MANAGER

by W. FINLAYSON Director, Commonwealth Forestry Bureau

An attempt is made to review all the means by which a forestry field manager acquires technical information. The difficulties created by the increasing flood of information, and the need to manage it and systematically select what is useful, are discussed. An assessment is made of the 'information behaviour' of forestry field managers.

A critical view is taken of the way in which the forestry literature is created at present, and suggestions are made for improvements. There is a brief discussion of some traditional procedures, and applications of new technology, that are aimed at making the literature more accessible.

It is suggested that information science should be recognized as an essential branch of forestry, particularly in education and training.
The Commonwealth Forestry Institute (CFI) developed from a small beginning in 1905, when a School of Forestry was established in Oxford to train foresters for the Indian Empire. The crisis of timber supplies during and after the First World War led to the decision of the Empire Forestry Conferences of 1920 and 1923 to found an Imperial Forestry Institute in Oxford to undertake research and teaching in forestry for countries of the British Empire. The IFI opened in 1924. In 1938 the Institute and the School of Forestry were fused under the sole direction of the Professor of Forestry. The present handsome building was erected by the University with generous donations from the Rajah of Sarawak, the Colonial Development and Welfare Trust, the Rhodes Trust and the Pilgrim Trust; it was formally opened in 1950 by HRH Princess Margaret.

In 1961 the present name of the Institute was adopted and, during the sixties, activities in overseas education and research developed significantly, with funding from many Commonwealth countries and the UK Ministry of Overseas Development, now the Overseas Development Administration (ODA). Since 1969 these activities on behalf of developing countries have been grouped to form the Unit of Tropical Silviculture (UTS) which is financed from the Overseas Education and Research Fund.

Thus today the CFI comprises two main elements: the Oxford University Department of Forestry, which provides academic, technical and other staff, laboratories and library services; and the Unit of Tropical Silviculture (UTS), providing research and training, funded by ODA and other Commonwealth governments. The CFI building also accommodates the Commonwealth Forestry Bureau (CFB, a literature abstracting service which is part of the independent Commonwealth organisation, the Commonwealth Agricultural Bureaux) and the Commonwealth Forestry Association (a professional association for all concerned with the conservation, development and management of forests).

Since the early sixties many of the research and training activities of the CFI have been in response to recommendations from the Commonwealth Forestry Conferences. This paper summarises these activities in the light of the recommendations of the Eleventh Conference in Trinidad in 1980. Details of the present status of the Institute, its programme, organisation, staffing and funding are given.

Most of the tropical research work in the CFI is carried out under projects founded by ODA. During the last five years 12 projects were completed; many of these were direct outcomes of the recommendations of the Eleventh Conference and the prevailing international priorities in tropical forest research. The Commonwealth contributions to the Institute have funded areas of research not covered by projects, maintenance of databases, taxonomic services and training. Fuller details of individual projects and other research are given in the annual reports of the CFI and the UTS. An external review of all ODA-funded forestry research for the period 1976–1982 has recently been completed.
Co-ordination of aid activities within the forestry sector can improve their effectiveness; co-ordination with related sectors in development planning may strengthen the resources available for forestry development. In the global and broad economic context the most significant means to co-ordination are provided by the major regional and international organisations, particularly the World Bank, the OECD Development Assistance Committee (DAC), UNDP and FAO. However, the larger the forum and the broader the sectoral and geographical range of interests, the less precise is the influence on action. Most effective co-ordination is at sectoral level and for bilateral aid must take place within, or at least with the guidance of, the recipient country.

The greatest benefits from co-ordination lie in forward planning but this may be restricted in advance of formal agreements. Sector reviews and master plans for sector development are valuable as a context for aid co-ordination. Major changes in the needs and opportunities in the forestry sector necessitate such reviews of policy and of activities in research, education and training. The common heritage of many Commonwealth countries in these fields provides a basis for review and planning, assisted where necessary by bilateral aid. Co-ordination of these activities could lead to more effective technical co-operation between Commonwealth countries in ways not exclusive but possibly catalytic to broader co-ordination.
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THE PERFORMANCE OF MOBILE SAWMILLS IN NORTHERN TANZANIA

By G. S. KOWERO¹, S. E. KALAGE² and A. O'KTING'ATI¹

SUMMARY

The re-introduction of mobile sawmills in Tanzania in the early 1980s has been due to the absence of enough industrial capacity to process thinnings from softwood plantations; a situation which has been worsened by windfalls in unthinned plantations.

These sawmills are characterized by relatively low capital investments and a high degree of flexibility in terms of their location and labour skills for their operation. These advantages have facilitated the profitable operation of two such sawmills in northern Tanzania. Such results should encourage their introduction into other forest plantations and in countries facing a similar problem of handling small dimension logs.

RÉSUMÉ

La réintroduction des scieries mobiles en Tanzanie aux années 80 s’explique par l’absence de la capacité industrielle pour l’utilisation des éclaircies des plantations résineuses, une situation aggravée par les chablis des peuplements non éclaircies. Ces scieries exigent un investissement modeste et sont très flexible quant à leur localisation et leur main d’oeuvre. Ces avantages ont favorisés l’opération de deux de ces scieries en Tanzanie du nord. Les résultats devraient encourager leur introduction dans d’autres plantations et dans les pays affligés par le même problème.

RESUMEN

La reintroducción de aserraderos móviles en Tanzania en los primeros años de la década de los ochenta se ha debido a la ausencia de suficiente capacidad industrial para procesar el producto de los raleos de plantaciones de coníferas. Esta situación ha empeorado debido a la caída de árboles causada por el viento en plantaciones no raleadas.

Estos aserraderos se caracterizan porque requieren una inversión relativamente baja y presentan un alto grado de flexibilidad en lo que se refiere a su ubicación y la habilidad del personal necesario para su operación. Estas ventajas han facilitado la operación rentable de dos aserraderos de este tipo en el norte de Tanzania, lo cual debería estimular su introducción en otras áreas forestales y países que enfrenten problemas similares.

Introduction

Most of the planning institutions and forest services of developing countries endowed with forest resources recognise the importance of forest industries as one of the tools which can effectively be used to alleviate economic under development. The power of such industries arises from their special features which as summarised by Westoby (1962) include:

— the ability of forest industries to offer a wide product range both of consumer and intermediate goods,

¹ Department of Forest Economics, Sokoine University of Agriculture, Morogoro, Tanzania.
² Forest Training Institute, Olmotonyi, Arusha, Tanzania.
— the production of intermediate goods could lead to the establishment of industries based on these products,
— they have a strong backward linkage to a renewable natural resource that can be grown relatively cheaply in tropical countries;
— factories could be established in rural areas close to the resource base thus assisting balanced economic growth,
— they have relatively low capital investment with a relatively high labour content.

Of all forest industries, the sawmilling industry is usually the first to be established in many countries. This is mainly because the required initial investment can usually be kept moderate, the industry is very flexible in terms of labour skills as exhibited by the relatively low technical skills required for pit sawing to very specialised skills required in most modern sawmills.

In Tanzania, a country with almost half of its area under forest cover, one would expect forest industries, capitalising on these advantages, to play a very prominent role in the economic development of the country. However as noted by Jaakko Pöyry (1980) the contribution of the forestry sector to national development averages 3% of the Gross Domestic Product. Also Dykstra (1983) notes that forestry labour comprises 2.8% of the paid employment in Tanzania. Apart from the numerous intangible benefits of forestry, certainly this tangible contribution is small especially when compared with the forest resource base. The reason is primarily due to lack of manufacturing capacity in the forest products industry.

Most of the wood processing capacity is presently in the sawmilling industry and largely dealing with hardwoods. It ranges from pit sawing to relatively advanced sawmilling. However the country has established softwood plantations which are mostly ripe for harvest and there is a significant shift in terms of investments in processing facilities with emphasis on utilising plantation grown timber. Since the early 1970s investments have been made in wood based panel factories including a particleboard mill and a hardboard mill.

Most of the large and modern sawmills, together with these panel factories, rely on wood raw materials from softwood plantations. A pulp and paper factory also based on a similar raw material base will become operational in 1985.

Despite all this shift in emphasis, the softwood raw material supplies will continue to be out of phase with the development of the relevant industrial capacity. According to the Ministry of Natural Resources and Tourism (1983) there is an excess in the annual allowable cut of the softwood plantations of 300,000 m³ and this is estimated to reach 600,000 m³ by 1990. Insufficient funding of plantation management activities together with inadequate industrial capacity to cope with this excess supply, have in some forest plantations postponed harvesting, especially those of thinnings, with the consequence that windfalls are on the increase.

Funding constraints, especially those of foreign origin to import more processing equipment, have motivated planners to look for alternative cheaper ways of handling this surplus by at least containing the windfalls through the harvest of the thinnings. Such a re-thinking has resulted into a government-led introduction of mobile sawmills in the plantations since the early 1980s. These, according to the Ministry of Natural Resources and Tourism (1983), have the following advantages:

— capacity can be made available without the type of delays accompanying other types of sawmill planning and erection,
— sawing can be done at logging site thereby reducing transport costs in terms of volume of waste and dead weight left behind in the forest,
— mobile sawmills can handle small dimension logs, like those from thinnings,
— such sawmills are not as demanding in terms of technical skills as other sawmills,
they are relatively cheap as compared with other sawmills and are more labour intensive.

This paper seeks to examine the performance of three mobile sawmills which have been operational in the West Kilimanjaro Forest Project and Sokoine University of Agriculture (SUA) Training Forest, both in northern Tanzania.

SUA Training Forest has been operating a mobile sawmill since 1981. It has a rated output capacity of 10 m³ per day but it is used for both training and commercial purposes. West Kilimanjaro Forest Project started operating two mobile sawmills in 1982 whose rated output capacity is 20 m³ per day. These sawmills saw pine and cypress timber.

Methodology
The sawmills were visited in 1984 and data on their production activities collected. The SUA Training Forest Sawmill records its data according to financial years while in the West Kilimanjaro Sawmill, data is recorded by calendar years. The figures provide a basis for examining the profitability.

Results and Discussion

Productivity
On the basis of records available at the mill offices the production record of the sawmills is summarised in Tables 1 and 2.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Sawnwood Production at SUA Sawmill</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Item</strong></td>
<td><strong>Units</strong></td>
</tr>
<tr>
<td>Input volume</td>
<td>m³(r)</td>
</tr>
<tr>
<td>Output volume</td>
<td>m³(s)</td>
</tr>
<tr>
<td>Recovery rate</td>
<td>%</td>
</tr>
<tr>
<td>Work days</td>
<td>no.</td>
</tr>
<tr>
<td>Production/day</td>
<td>m³/day</td>
</tr>
</tbody>
</table>

* Data for six months only.
**Data for nine months only (sawmill became operational in October 1981).

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Sawnwood Production at W. Kilimanjaro Sawmill</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Item</strong></td>
<td><strong>Units</strong></td>
</tr>
<tr>
<td>Input volume</td>
<td>m³(r)</td>
</tr>
<tr>
<td>Output volume</td>
<td>m³(s)</td>
</tr>
<tr>
<td>Recovery rate</td>
<td>%</td>
</tr>
<tr>
<td>Work days</td>
<td>no.</td>
</tr>
<tr>
<td>Production/day</td>
<td>m³/day</td>
</tr>
</tbody>
</table>

In both sawmills the productivity in the first year is low but increases later. This is because many of the employees were familiarising themselves with the various sawmilling activities. This is consistent with the observation made by Yelle (1979) that as an individual worker or crew continually repeats the process productivity shows gradual and predictable improvement.
However productivity is much lower at the SUA Training Forest sawmill because most of the workers had no formal training or experience in sawmilling when the mill became operational. Of the six permanently employed workers of the sawmill, only the sawmill manager had some formal training. Also it can be deduced that this sawmill is most probably handling smaller dimension logs than the West Kilimanjaro Sawmill. This is evidenced from the declining recovery rates over the years (Table 1) despite the increase in sawing experience.

Given a designed daily output capacity of 10 m$^3$ for SUA Training Forest Sawmill, the noted productivity is very low leaving a very big room for improvement. This calls for more workers training to upgrade their sawing skills, increased supervision of sawing operations and motivating the workers through the payment system e.g. by the introduction of a bonus payment. Money related motivation usually increases productivity because workers on their own accord, normally eliminate waste time within their control. As such, a bonus system generally increases the sense of responsibility amongst the workers.

As regards West Kilimanjaro Sawmill, productivity doubled in 1982–83 mainly due to the introduction of a bonus payment system. In 1983 alone, workers received a total of shs. 67,700 as wage related motivation. This sawmill employs fifteen permanent workers on its two units. However, the productivity is still low as compared with its rated output capacity of 20 m$^3$ per day for the two units.

Both sawmills, in addition to training and supplying money related motivation for their workers, need to increase their operations to two shifts per day to enable the full utilisation of their capacities. With respect to SUA Training Forest Sawmill some of its capacity is for research and training purposes. This is presently low and negligible in the period of this analysis but with increase in research activities it may reach 20–30% of the capacity. An allowance for this should be made when appraising it commercially.

**Production costs**

These have been classified according to five cost centres namely raw material (royalties and logging) capital (depreciation of machinery, buildings and vehicles, and insurance) running (including fuel, oil and lubricants) and overheads (including office expenses, audit fees, supervision and administration). The trend of these cost components over the years together with their contribution to total production costs is analysed.

| Table 3 |
| Production Costs for SUA Sawmill |

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>1981/82</th>
<th>1982/83</th>
<th>1983/84</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material</td>
<td>shs</td>
<td>82,962</td>
<td>(23.5)*</td>
<td>330,144</td>
</tr>
<tr>
<td>Capital</td>
<td>shs</td>
<td>37,133</td>
<td>(10.5)</td>
<td>49,486</td>
</tr>
<tr>
<td>Labour</td>
<td>shs</td>
<td>83,250</td>
<td>(23.6)</td>
<td>111,000</td>
</tr>
<tr>
<td>Running</td>
<td>shs</td>
<td>42,357</td>
<td>(12.0)</td>
<td>66,375</td>
</tr>
<tr>
<td>Overheads</td>
<td>shs</td>
<td>107,692</td>
<td>(30.4)</td>
<td>199,125</td>
</tr>
<tr>
<td>Total costs</td>
<td>shs</td>
<td>353,374</td>
<td>(100.0)</td>
<td>756,130</td>
</tr>
<tr>
<td>Total production</td>
<td>m$^3$(s)</td>
<td>255</td>
<td></td>
<td>731</td>
</tr>
<tr>
<td>Unit production</td>
<td>sh/m$^3$</td>
<td>1,388</td>
<td></td>
<td>1,035</td>
</tr>
</tbody>
</table>

*percent of total costs.

**Raw material**

For SUA Training Forest Sawmill the logging operations are performed by the Training Forest staff while for West Kilimanjaro Sawmill the logging operations are performed by a specialised Logging and Road Building Unit of the Ministry of Lands, Natural
Resources and Tourism. The efficiency with which these separate logging groups operate affects raw material costs and their contribution to production costs. However the shifting of the SUA Training Forest Sawmill from the forest to the Training Forest Station in 1983 increased log delivery costs, compared with those of the West Kilimanjaro Sawmill, which is located in the forest. With the sawmills operating in the forests raw material costs as a percentage of total production costs range from 23.5% for SUA Training Forest Sawmill in 1981/82 to about 30%, the average for W. Kilimanjaro Sawmill. Shifting the SUA Training Forest Sawmill to the Training Forest Station increases log cost deliveries making the proportion of the raw material costs in total production to increase from 23.4% in 1981/82 to 45.3% in 1983/84. Therefore to cut down on sawmilling costs mobile sawmills should be brought to the raw material.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Production Costs for W. Kilimanjaro Sawmill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Unit</td>
</tr>
<tr>
<td>Raw material</td>
<td>shs</td>
</tr>
<tr>
<td>Capital</td>
<td>shs</td>
</tr>
<tr>
<td>Labour</td>
<td>shs</td>
</tr>
<tr>
<td>Running</td>
<td>shs</td>
</tr>
<tr>
<td>Overheads</td>
<td>shs</td>
</tr>
<tr>
<td>Total costs</td>
<td>shs</td>
</tr>
<tr>
<td>Total production</td>
<td>m³/s</td>
</tr>
<tr>
<td>Unit production</td>
<td>sh/m³</td>
</tr>
</tbody>
</table>

*percent of total costs

**Capital**
For SUA Training Forest Sawmill the capital proportion in total production costs varies from 6.5% to 10.5% while that of W. Kilimanjaro Sawmill varies from 21.0% to 24.4%. The difference is mainly due to the use of different machinery and of different initial values but applying the same depreciation method. SUA Training Forest Sawmill operates a KA-RA unit while W. Kilimanjaro operates Lindqvist units. Also W. Kilimanjaro Sawmill, as a subsidiary company of Tanzania Wood Industry Corporation (TWICO) has more capital equipment to make it operational as a company. These differences notwithstanding, the mobile sawmill industry in northern Tanzania is not capital intensive.

**Labour**
With the exception of 1981/82, the first year of operation of SUA Training Forest Sawmill, where labour comprised 23.6% of total production costs, both sawmills have low labour costs ranging from 13.8% to 14.7%. This is because of the employment of a casual labour force in logging and also as noted earlier, the sawmills employed cheap and relatively unskilled permanent workers when they became operational.

**Running costs and Overhead costs**
The running costs have been relatively low, ranging from 5.7% to 12% of total production costs. Overhead costs have been fairly high ranging from 23.3% to 30.4% of total production costs.

However for SUA Training Forest Sawmill there has been an effort to decrease the proportion of these costs in total production costs. Running costs have decreased from 12% in 1981/82 to 7.8% in 1983/84 of total production costs while overhead costs have decreased from 30.4% in 1981/82 to 25.6% in 1983/84. W. Kilimanjaro Sawmill had
managed to reduce the running costs component in total production costs from 8.1% in 1982 to 5.7% in 1983 but it appears to have failed to curb overhead costs since their proportion increased from 23.3% in 1982 to 29.2% in 1983.

Running and overhead costs are largely within the manipulation of the management.

*Unit production costs*
Despite differences in machinery, locality, management and levels of skills, the unit production costs for both sawmills are quite similar.

*Profitability*
For each year of operation the level of profitability was assessed as summarised in Tables 5 and 6.

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Profitability of SUA Sawmill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Units</td>
</tr>
<tr>
<td>Revenue</td>
<td>sh/m³</td>
</tr>
<tr>
<td>Cost of production</td>
<td>sh/m³</td>
</tr>
<tr>
<td>Profit</td>
<td>sh/m³</td>
</tr>
<tr>
<td>Profit margin</td>
<td>%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 6</th>
<th>Profitability of W. Kilimanjaro Sawmill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Units</td>
</tr>
<tr>
<td>Revenue</td>
<td>sh/m³</td>
</tr>
<tr>
<td>Cost of production</td>
<td>sh/m³</td>
</tr>
<tr>
<td>Profit (loss)</td>
<td>sh/m³</td>
</tr>
<tr>
<td>Profit margin</td>
<td>%</td>
</tr>
</tbody>
</table>

SUA Training Forest Sawmill shows an increasing profitability over the years as illustrated by very high profit margins. However the profitability of W. Kilimanjaro Sawmill is lower than that of SUA Training Forest Sawmill despite their unit production cost being almost the same. This is because of the adoption of different sawn timber pricing systems since the mills belong to different owners and serve different markets. It will be more profitable for W. Kilimanjaro Sawmill to look for better markets since SUA Training Forest Sawmill shows that there are consumers who are willing to pay higher prices than the customers served by W. Kilimanjaro Sawmill.

*Conclusions*
The study has shown that despite an initial lack of skills and low levels of production, mobile sawmilling has proved to be a very profitable venture in softwood plantations in northern Tanzania. As a consequence, investments of this type need encouragement and efforts should be made to promote such sawmilling practices in other areas of the country as well. Given the level of skills needed and the relatively small investments required, villages bordering forest plantations ought to be encouraged to engage in mobile sawmilling to supplement revenues. In addition to the provision of jobs, the sawn timber will be available for building and furniture.
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WOOD AS A SOURCE OF FUEL IN UPPER SHABA (ZAÎRE)*

By F. MALAISSE and K. BINZANGI**

SUMMARY
At the beginning of the 20th century the creation of mining towns in Upper Shaba brought about the development of large urban centres and a resulting increase in their wood needs. The surrounding vegetation, mainly open forest, was exploited. Today the forest, for 70 km around Lubumbashi, is menaced with destruction, whilst an area of 30 km radius has already been completely clear-cut. Only unproductive derived savannas and a few rare vegetable plots in the valleys have replaced it.

The present stage of destruction of the original forest has reduced forest product capital by 19%, and future developments indicate complete deforestation of the square degree of Lubumbashi in 2050. Plantation and afforestation solutions are known, but the probability of their being applied in the coming years is slight, even though just 20% of the area being given over to forestry would be enough to satisfy the woodfuel needs of the population.

RESUME
Au début de ce siècle le développement des mines dans le Chaba supérieur a créé de nouveaux centres urbains ayant des besoins importants en bois. La végétation des alentours, en grande partie de la forêt était mise en exploitation. Aujourd'hui sur un rayon de 30 km autour de Lubumbashi rien ne reste, et le menace de destruction pèse sur un rayon de 70 km. Seules les savannes secondaires et pauvres subsistent, mis à part quelques champs de légumes dans les vallées.

L'état actuel de la forêt représente la perte de 19% du capital forestier, et l'on prévoit le déboisement total du dégré carré autour de Lubumbashi d'ici l'an 2050. Les solutions par le reboisement existent mais ne seront probablement pas appliquées à temps, bien que 20% de la superficie soit suffisant pour subvenir aux besoins en bois de chauffage de toute la population.

RESUMEN
En los inicios del siglo 20 la creación de pueblos mineros en Upper Shaba resultó en el desarrollo de grandes centros urbanos. Esto trajo como consecuencia un aumento en sus necesidades por productos forestales y la explotación de los bosques aledaños. Actualmente 70 km de bosques alrededor de Lubumbashi se encuentran en peligro de destrucción, mientras que el area en un radio de 30 km ya ha sido completamente devastada, solamente reemplazada por savanas improductivas y escasas parcelas agrícolas en los valles.

La destrucción de bosques hasta el momento ha reducido la capital de productos forestales por un 19% y se crea que la explotación futura dejará completamente deforestada un area de 100 km por 100 km alrededor de Lubumbashi en el año 2050! La solución mediante reforestación es bien conocida pero la posibilidad de su aplicación en los años venideros es remota, aún cuando el 20% del area, si fuera plantaciónes, sería suficiente para satisfacer las necesidades para leña de la población.

Introduction

* Contribution No. 55 to the study of the Miombo open forest ecosystem.
** Respectively Head and First Assistant, Laboratoire de Botanique et d' Ecologie, University of Lubumbashi, B.P. 3429, Lubumbashi, Zaïre.
consumed in the world came from traditional sources, of which wood was by far the most important. Today, developed countries, with a total of 1.2 billion inhabitants consume 5/6ths of conventional energy, whereas the less developed countries (LDCs), with a population evaluated at more than 3 billion, consume less than one sixth (Revelle 1980). This state of affairs is linked to the fact that the LDCs use large amounts of non-commercial energy derived mainly from wood transformed to a greater or lesser extent. Thus in the LDCs 80% of the population depends on woodfuel as their primary energy source (Openshaw 1974). In 1971 woodfuel was estimated to provide 75% of energy in sub-Saharan countries, and to exceed 90% in some countries (Earl 1975).


This preoccupation is justified by the fact that organic combustible materials are the major energy source for most African countries (Table 1) and concern the vast majority of their populations.

The creation of large urban agglomerations has caused a concentrated demand for wood and a dispersed supply, bringing about commercialisation and this has had far-reaching consequences when wood merchants compete for a resource without being responsible for protecting or replacing it (Gandar 1984).

The deforested zones surrounding large African towns are reaching alarming proportions (Table 2). Thus more than 60,000 m$^3$ of indigenous wood was trucked into Harare in 1980 from as far as 120 km away (Whitlow in Gandar 1984). In the Ivory Coast, over 18 years (from 1956 to 1974), more than six million hectares of rain forest were cleared and became fields, fallow lands or secondary bushlands (Monnier 1981). This ever-increasing deforestation augurs a growing scarcity of firewood.

In Zaire, wood represents around 76% of the global energy consumption (Binzangi 1983). However the wood production in the different regions of Zaire is very variable. Forested areas alternate with grasslands. In fact, botanists distinguish 11 phytogeographical districts, each with its own individual characteristics. The following discussion only concerns one of these, Upper Shaba (Figure 1). This phytogeographical entity is integrated into a larger, relatively homogeneous area, namely the Zambezian region (White 1976), where woodland dominates (CSA 1956, 1960, Malaisse 1978). In order to evaluate deforestation dynamics in this area, we followed the evolution of the vegetal cover on a basis of cartographic documents and aerial photographs. The square degree of Lubumbashi (27–26° longitude East, 11–12° latitude South) was chosen as a reference. This choice is justified by our close knowledge of the land at ground level in this area, as well as by the recent publication of a map of the vegetation (Malaisse
Table 2
Size of the deforested area, of the firewood volume and number of charcoal sacks consumed by some large African cities.
(1): values obtained on the premise that one charcoal sack weighs 48 kg; (2): this amount of wood equals 864 hectares of evergreen forest exploitation; (3): estimation of the population’s wood needs (after Malaisse et al. 1980, modified).

<table>
<thead>
<tr>
<th>Town (Country)</th>
<th>Number of inhabitants (reference year)</th>
<th>Approximate radius of the deforested area (km)</th>
<th>Firewood volume (Mm³/yr)</th>
<th>Number of charcoal sacks Thous./yr</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abidjan (Ivory Coast)</td>
<td>600,000 (1971)</td>
<td>—</td>
<td>0.06</td>
<td>288^(2)</td>
<td>Monnier (1972)</td>
</tr>
<tr>
<td>Bamako (Mali)</td>
<td>200,000 (1970)</td>
<td>over 100</td>
<td>—</td>
<td>—</td>
<td>Le Houérou (1977)</td>
</tr>
<tr>
<td>Dakar (Senegal)</td>
<td>799,000 (1976)</td>
<td>—</td>
<td>0.066</td>
<td>1502</td>
<td>Berlureau and Berlureau (1984); Pagni (1975)</td>
</tr>
<tr>
<td>Kano (Nigeria)</td>
<td>342,610 (1971)</td>
<td>over 100</td>
<td>—</td>
<td>—</td>
<td>Le Houérou (1977)</td>
</tr>
<tr>
<td>Karthoum (Sudan)</td>
<td>262,000 (1971)</td>
<td>90</td>
<td>—</td>
<td>—</td>
<td>Eckholm (1978)</td>
</tr>
<tr>
<td>Kinshasa (Zaire)</td>
<td>2,000,000 (1979)</td>
<td>50</td>
<td>1.2^(3)</td>
<td>—</td>
<td>Bride in Pain (1979)</td>
</tr>
<tr>
<td>Kisangani (Zaire)</td>
<td>425,000 (1980)</td>
<td>15</td>
<td>—</td>
<td>—</td>
<td>Harroy (1979)</td>
</tr>
<tr>
<td>Kolwezi (Zaire)</td>
<td>218,000 (1982)</td>
<td>over 20</td>
<td>0.034</td>
<td>411</td>
<td>Binzangi (1983)</td>
</tr>
<tr>
<td>Likasi (Zaire)</td>
<td>200,000 (1982)</td>
<td>20</td>
<td>0.031</td>
<td>376</td>
<td>Binzangi (1983)</td>
</tr>
<tr>
<td>Lubumbashi (Zaire)</td>
<td>534,000 (1980)</td>
<td>30</td>
<td>0.06</td>
<td>418</td>
<td>Schmitz (1974)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Leblanc and Malaisse (1978)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Binzangi (1983)</td>
</tr>
<tr>
<td>Lusaka (Zambia)</td>
<td>448,000 (1972)</td>
<td>70</td>
<td>—</td>
<td>54</td>
<td>Brown (1978)</td>
</tr>
<tr>
<td>N'Djamena (Tchad)</td>
<td>150,000 (1971)</td>
<td>over 100</td>
<td>0.1</td>
<td>—</td>
<td>Le Houérou (1977)</td>
</tr>
<tr>
<td>Niamey (Niger)</td>
<td>100,000 (1970)</td>
<td>over 100</td>
<td>0.1</td>
<td>—</td>
<td>Le Houérou (1977)</td>
</tr>
<tr>
<td>Ouagadougou (Upper Volta)</td>
<td>260,000 (1980)</td>
<td>75 to 100</td>
<td>0.146</td>
<td>—</td>
<td>Ouédraogo and Vennetier (1977)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>70 to 100</td>
<td>0.114</td>
<td>31</td>
<td>Chauvin (1981)</td>
</tr>
<tr>
<td>Pointe-Noire (Congo)</td>
<td>100,000 (1970)</td>
<td>20</td>
<td>0.120</td>
<td>—</td>
<td>Vennetier (1968)</td>
</tr>
<tr>
<td>Sokoto (Nigeria)</td>
<td>45,000 (1970)</td>
<td>over 100</td>
<td>0.1</td>
<td>—</td>
<td>Le Houérou (1977)</td>
</tr>
<tr>
<td>Zinder (Niger)</td>
<td>45,000 (1970)</td>
<td>over 100</td>
<td>0.1</td>
<td>—</td>
<td>Le Houérou (1977)</td>
</tr>
</tbody>
</table>
et al. 1983). This latter distinguishes 8 different vegetation types. Our estimations of firewood reserves have been established for these 8 sections.

Open forest is the most widespread vegetation type. Although reputed poor (Delevoy 1928), it provides products that may be grouped as follows: charcoal, firewood, fuelwood, construction wood and wood for industrial purposes (Malaisse et al. 1980). Open forests and woodlands are important producers of lightweight poles and fuel for the local population. Only a few species in the Miombo woodlands have the dimensions necessary for heavy construction (de Vos 1975, Liengwe 1981). The most important products are charcoal and firewood which represent respectively 73 and 18% of the need for woody combustible material in Lubumbashi.

The present study follows the evolution of wood reserves in Upper-Shaba from the beginning of the century, and sketches out the main characteristics of future evolution.

![Photo 1. View of Miombo type open forest near Lubumbashi.](image)

**Charcoal yield of the different types of open forests and wooded savannas**

Studies on charcoal production in Upper Shaba generally distinguish small-scale production from that performed by steel ovens. Today this latter technique only continues at Kikeka.

Traditional production involves well known successive stages, which are felling, chopping, collecting and piling of the logs, these being covered by clods of earth, their charring, uncovering and packing in sacks (Delevoy 1948, Misson 1952, Schmitz and Misson 1960, Binzangi 1983).

In order to estimate the wood reserves in the area studied, several methods of quantification were tested and compared. Production may in fact be expressed in terms of the area deforested, the basal area values, the gross volume of the logs, the net volume of wood to be charred, the volume of the charcoal stack, or lastly the weight or volume (number of sacks) of charcoal produced.
To fix a precise relationship between these methods of expression is not easy. One source of miscalculation for the weight may be found in the variable hydration of charcoal: 18.5% in April (end of rainy season), 1.5% in October (dry season). As for production measured in sacks, the volume of these may vary, and in addition there may, or may not be an overload in mushroom form.

The deforested area does not give a concise evaluation as in this region is found a mosaic of woodland types with very variable density. Early studies (Delevoy 1928) furthermore distinguish 5 classes of productivity for the ‘wooded savannas’ of Upper Shaba. Today, phytogeographers (CSA 1956) and ecologists define 4 types of ‘wooded savannas’: open forest, wooded savanna in the strict sense of the term, tree savanna and shrub savanna.

Basal area has been found to be a precise, useful method of distinguishing the 4 vegetation types noted below (Table 3); unfortunately there are large differences between the basal area of a tree, and its above-ground wood volume.

The volume of the charcoal pile is a very consistent method of evaluation, especially when small stacks, where the earth covering forms a large part of the whole, are not included. In the end, the net volume of chopped wood was found to be the most precise factor, its only weakness being in the variation of specific density of tree species which causes a slight variation in yield. However, evaluation by this method is long and laborious.
Table 3
Charcoal production per hectare for different vegetation types in Upper Shaba.

<table>
<thead>
<tr>
<th>Vegetation type</th>
<th>Number of stems per hectare</th>
<th>Basal area (m²/ha)</th>
<th>Wood (net volume) (m³/ha)</th>
<th>Volume of charcoal stack (m³/ha)</th>
<th>Number of charcoal sacks/ha</th>
<th>Charcoal (T/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riparian forest</td>
<td>—</td>
<td>27</td>
<td>130</td>
<td>333.6</td>
<td>27.7</td>
<td>484.5</td>
</tr>
<tr>
<td>Dry evergreen forest</td>
<td>1463</td>
<td>33</td>
<td>150</td>
<td>384.9</td>
<td>229.4</td>
<td>333</td>
</tr>
<tr>
<td>Open forest</td>
<td>570</td>
<td>19</td>
<td>80</td>
<td>205.3</td>
<td>11.5</td>
<td>229.4</td>
</tr>
<tr>
<td>Wooded savanna</td>
<td>210</td>
<td>11</td>
<td>30</td>
<td>76.9</td>
<td>4.4</td>
<td>76.9</td>
</tr>
<tr>
<td>Tree and shrub savanna</td>
<td>45</td>
<td>2</td>
<td>4</td>
<td>10.3</td>
<td>0.7</td>
<td>4.4</td>
</tr>
</tbody>
</table>

To establish the relationships between these forms of evaluation we conducted about thirty experiments, made in 3 different localities (Luiswishi, Mususwa and Tumbwe; These experiments include a forest inventory over 5 hectares and wood felling on more than 3.5 hectares (more than 1,000 felled trees were measured). From this enormous mass of data we obtained the following average relationships.

- 1 ha of open forest equals 570 trees whose diameter $\geq 5.0$ cm (Malaisse 1982);
- 1 ha of open forest equals 363 trees whose diameter $\geq 10.0$ cm (Malaisse 1982);
- 1 ha of open forest equals $(15) - 19 - (25)$ m² of basal area (Malaisse 1982);
- 1 ha of open forest equals $\pm 80$ m³ of wood (net volume) (Binzangi 1983);
- 1 m³ wood (net volume) equals 2.566 steres (Malaisse et al. 1980);
- 1 m³ steres equals 1.1 m³ charcoal stack (Binzangi 1983);
- 1 m³ of charcoal stack produces $(1.0) - 1.3 \pm 0.2 - (1.8)$ sacks of charcoal (Binzangi 1983);
- 1 sack of charcoal weighs $48.3 \pm 5.6$ kg (Malaisse et al. 1980).

The square degree of Lubumbashi

There has been, and still exists, a long controversy as to the nature of the climatic vegetation in Upper Shaba. Some (Schmitz 1962, 1971) consider that the dry evergreen forest is the most luxurious vegetation in balance with the soil and the climate in Upper Shaba, and that without the intervention of man it would be omnipresent. Other authors (Duvigneaud 1958, Stree 1963) defend the theory of a mosaic of open forests and dense climatic forests whose relative importance would vary with changes in the regional climate.

The earliest information available today on the Lubumbashi area dates from the beginning of the 20th century and is composed of various accounts, completed with ancient photographic documents, made by travellers (1910–1915) as well as a vegetation map of the Lubumbashi area (Sys and Schmitz 1959). The analysis of this information, together with an examination of the existing vegetation cover generally reveals the vegetation of the years 1900–1920.

We used this technique, which enabled us to define the main tendencies of the evolution of the vegetation in the studied region (Table 4). At the beginning of the 20th century, 85 per cent of the square degree of Lubumbashi was covered by open forest. However this and other forest types covered more than 92%. The first deforested areas appeared around 1910, with:

- copper exploitation;
- the creation of Lubumbashi and Kipushi towns;
- construction of the railroad (clearing for construction and sleepers);
WOOD FUEL IN ZAIRE

— woodfuelling of steam engines;
— the creation of farms and rural centres around the towns;
— the appearance on the market of woodfuels, such as charcoal.

Table 4
Area and relative importance of the types mapped in the square degree of Lubumbashi (Zairian sector)*

<table>
<thead>
<tr>
<th>Type</th>
<th>Original vegetation cover (beginning of century)</th>
<th>Present vegetation cover</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area</td>
<td>%</td>
</tr>
<tr>
<td>Open forest</td>
<td>884,675</td>
<td>83.76</td>
</tr>
<tr>
<td>Wooded savanna</td>
<td>40,347</td>
<td>3.82</td>
</tr>
<tr>
<td>Tree and shrub savanna</td>
<td>40,348</td>
<td>3.82</td>
</tr>
<tr>
<td>Dambo</td>
<td>39,429</td>
<td>3.73</td>
</tr>
<tr>
<td>Grassy alluvial or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acacia-dominated savanna</td>
<td>34,920</td>
<td>3.31</td>
</tr>
<tr>
<td>Dense riparian forest</td>
<td>7,877</td>
<td>0.75</td>
</tr>
<tr>
<td>Marshy vegetation</td>
<td>7,747</td>
<td>0.73</td>
</tr>
<tr>
<td>Cupriferous steppe-type savanna</td>
<td>565</td>
<td>0.05</td>
</tr>
<tr>
<td>Dry evergreen forest</td>
<td>260</td>
<td>0.02</td>
</tr>
<tr>
<td>Derived savanna</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban zone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultivation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Afforestation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,056,168</td>
<td>99.99</td>
</tr>
</tbody>
</table>

*The evaluation of the cleared areas was made by adding together the surface areas of open forest and other vegetation types found in the deforested zone. In order to compensate for the cleared areas, the patches of open forest found inside this area have not been taken into account.

— The urban area has been estimated at 8,000 hectares: 7,000 hectares for Lubumbashi (Bruneau and Mbuyu 1983) and 1,000 hectares for Kipushi (Okito 1984).
— The area covered by cultivated fields was established on the basis of a systematic enquiry carried out in 1982–1983 in villages in the Zaïrian sector of the square degree of Lubumbashi (Malaisse and Ipanga 1985).
— Open water corresponds to the Lufira and Lubumbashi reservoirs. The Mwadingusha dam was built in 1930, then raised twice, bringing about a considerable increase in the open water surface area when compared with the original Lake Tshangalele. It covers at present 44,600 hectares (Goorts et al. 1961). Lubumbashi lake was created in 1962 and covers 40 hectares (Freson 1972).
— The Kimbembe plantation was created in 1959–1960 and covers around 1014 hectares. To this we added that of the Inera-Kipopo, which covers 140 hectares. These values were obtained from evaluations on the basis of 2 Landsat photos which appeared in 1973.

All these human activities caused ever-increasing deforestation. Although the use of electricity, coal and diesel oil by trains has relatively diminished the consumption of firewood, electricity has not brought about the same phenomenon in medium and small industries or in the home. The expansion of human activity has caused the demand for woodfuel to grow. In consequence, the different forest and woodland types have suffered a variable but considerable recession since the beginning of the century, viz:
— 97.9% for dense riparian forest
— 60.5% for woodland
— 60.5% for tree and shrub savannas
— 17.6% for open forest
— 15.4% for dense dry evergreen forest.
Taken as a whole, the total retreat of woodland and forest involves, 212,162 ha (1984), or 21.6%. Deforestation is still progressing, mainly along roads.

The comparison of present wood reserves with those of the beginning of the 20th century is revealing (Table 5): some 50.6 million sacks of charcoal have been consumed, thus diminishing the woodfuel capital by 18.8%.

### Table 5
Comparison of the firewood reserves in the Lubumbashi square degree (expressed in number of charcoal sacks) at the beginning of the 20th century and today (1984).

**Beginning of the 20th century**

<table>
<thead>
<tr>
<th>Type</th>
<th>Area (ha)</th>
<th>Production (charcoal)</th>
<th>Production (charcoal)</th>
<th>Tons</th>
<th>$10^3$ sacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense riparian forest</td>
<td>7,877</td>
<td>23,402</td>
<td>184,338</td>
<td>3,817</td>
<td></td>
</tr>
<tr>
<td>Dense evergreen forest</td>
<td>260</td>
<td>27,000</td>
<td>7,020</td>
<td>143</td>
<td></td>
</tr>
<tr>
<td>Open forest</td>
<td>884,675</td>
<td>14,403</td>
<td>12,650,852</td>
<td>261,922</td>
<td></td>
</tr>
<tr>
<td>Wooded savanna</td>
<td>40,347</td>
<td>5,395</td>
<td>217,672</td>
<td>4,507</td>
<td></td>
</tr>
<tr>
<td>Tree and shrub savanna</td>
<td>40,348</td>
<td>720</td>
<td>29,050</td>
<td>601</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>973,507</td>
<td></td>
<td></td>
<td>270,992</td>
<td></td>
</tr>
</tbody>
</table>

**The present day (1984)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Area (ha)</th>
<th>Production (charcoal)</th>
<th>Production (charcoal)</th>
<th>Tons</th>
<th>$10^3$ sacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense riparian forest</td>
<td>162</td>
<td>23,402</td>
<td>3,791</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Dense evergreen forest</td>
<td>220</td>
<td>27,000</td>
<td>5,940</td>
<td>123</td>
<td></td>
</tr>
<tr>
<td>Open forest</td>
<td>729,113</td>
<td>14,403</td>
<td>10,499,227</td>
<td>217,375</td>
<td></td>
</tr>
<tr>
<td>Wooded savanna</td>
<td>15,925</td>
<td>5,395</td>
<td>85,915</td>
<td>1,778</td>
<td></td>
</tr>
<tr>
<td>Tree and shrub savanna</td>
<td>15,925</td>
<td>720</td>
<td>11,466</td>
<td>237</td>
<td></td>
</tr>
<tr>
<td>Afforestation</td>
<td>1,154</td>
<td>33,540</td>
<td>38,705</td>
<td>801</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>762,499</td>
<td></td>
<td></td>
<td>220,392</td>
<td></td>
</tr>
</tbody>
</table>

### Prospects for future evolution

Forest farming has been an established practice in the Zambebian woodland area for centuries, almost entirely in the form of shifting cultivation. As long as there was only one or less cultivator per square kilometer (Malaisse 1979) and provided the patch of farmed forestland could be left fallow for at least fifty years in order to renew itself, the system worked well enough. But with the increase in population densities and their more sedentary lifestyle as well as the establishment of villages along the road network, people abandoned ecologically balanced subsistence strategies based on a wide range of available energy sources in favour of ecologically destructive concentrated exploitation, with the result that reforestation no longer occurred. Furthermore, along the timber tracks
some ‘subsistence’ cultivators created new settlement areas, and by clearing away more trees in order to plant their crops, they soon caused serious damage to, if not the destruction of, the open forest, as already underlined for the tropical moist forests by Myers (1981).

Lubumbashi town’s development, and the corresponding growth in its woodfuel needs poses the problem of how long the Lubumbashi square degree will be able to supply firewood. Although it is not possible to give a definite answer to this question at present, due to the large number of variables that must be taken into consideration, it is nonetheless possible to estimate the future.

The present and future urban and rural population numbers of the square degree of Lubumbashi are the first vital data. Two towns, very different in size, are built on the territory studied: Lubumbashi, the copper capital, and Kipushi, a company town, completely orientated around the mine. Although the population of the latter is known precisely (42,322 inhabitants in 1983), such is not the case for Lubumbashi. Different values have been proposed: 680,000 inhabitants in 1980 (Lootens-De Muynck et al. 1980), 586,000 inhabitants in 1980 (de Saint-Moulin 1977) and 580,000 in 1984 (Bruneau and Lootens 1984). Recent studies show that in the last 5 years immigration has considerably decreased. Thus the urban population can now only grow through its own dynamism (Bruneau, pers. comm.). Let us remember that even in 1977, de Saint-Moulin considered that the rate of growth in large Zaírian towns was slowing down, and tending to stabilise.

Using the 1984 figures, we have drawn up a plan of the developing woodfuel needs of the town, with two growth rates. Presupposing a growth rate of zero, both from a demographic point of view and from the annual average consumption per inhabitant (124.7 kgs), the square degree of Lubumbashi could supply wood up to the year 2120. On the other hand, taking into consideration an average annual demographic growth of 2% (Bruneau, pers. comm.), the last energy provided by woodfuel in the square degree of Lubumbashi would be consumed in 2050!

However, in the meantime there may be a change in lifestyles with an eventual increase in financial means of the working masses, which would clearly encourage the use of
petrol, natural gas and electricity, especially if reasonably priced cooking rings were to be developed. As far as charcoal production is concerned, taking into account a necessary increase in productivity and thus a change in charring methods, we may also hope for an improvement of production techniques, which would slow down deforestation. On a home and industrial level, consumption may also be reduced by improvement of charcoal burners and wood grates and by the conversion of industrial equipment.

Total deforestation of the square degree of Lubumbashi may also be avoided by a reforestation programme, which would provide constant supplies of woodfuel to Lubumbashi after a reasonable period. It must be noted here that not only has a reform in forest law been proposed (Schmitz 1969), but also that trials and a healthy start in Upper Shaba forestry have been made. As well as general observations relating to Shaban forests (Schmitz and Herinckx 1969), we also possess studies relating to Eucalyptus planting on burnt ground (Schmitz and Delvaux 1958), to Pine plantations (Misson 1952, Schmitz 1966) and to enrichment and tree selection in open forest (Schmitz 1959). Trials of other species (Schmitz et al. 1959, Schmitz 1966) have also given encouraging results. Woodyields may be found in the literature on the subject. Schmitz and Herinckx (1969) note that Eucalyptus saligna and E. camaldulensis, when 15 years old and on rich soil, may give 75 to 150 steres of wood (or 3.5 to 9 tons of charcoal). Schmitz (1969) calculates the yield of various Pinus (P. kesiya, P. patula, P. pseudostrobus), as being at 300–650 m³ of wood/ha, including thinning products, at 20 years of age.

In conclusion, artificial forests have an average yield per hectare 4 to 6 times greater than that of good natural open forest over 60 years old that has been clear-felled. Thus, in the framework of a reforestation programme destined to produce firewood, the problems relating to species choice and thinning techniques have already been resolved. Studies and trials on local noble species have unfortunately still to be done, and their slower growth does not encourage their substitution for exotic fast growing species.

The present needs of Lubumbashi could be met by a reforestation programme with a rotation period of 20–25 years, covering about 220 thousand hectares, or a little more than 20% of the territory. In this context, if a reforestation programme were perfected and applied, our predictions for the future would obviously have to be revised. However, pending these considerable changes, none of which are very likely, we should try to manage what remains rationally by changes in production and woodfuel consumption techniques. For, after copper, — we are in the Zârian Copperbow —, the open forest should be considered as the second treasure of Upper Shaba for a long time to come.

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WOOD FUEL IN ZAIRE


WOOD FUEL IN ZAIRE

Location of Upper Shaba and the Lubumbashi square degree.

The present cleared area around Lubumbashi and the main directions in which deforestation is progressing.
A NEW METHOD FOR ASSISTING SPECIES SELECTION

By T. H. BOOTH*

SUMMARY
This paper demonstrates how the Bioclimate Prediction System developed by Nix, Busby and Hutchinson can assist in identifying homoclime locations where species suitable for forestry would be worth testing. As an example, mean monthly values of maximum daily temperature, minimum daily temperature and precipitation were estimated using the BIOCLIM program for 84 locations within the natural range of *Eucalyptus citriodora*. From these values the program calculated 12 climatic parameters for each site. The variation in these parameters across the 84 sites provided an estimate of the climatic environment of *E. citriodora* in Australia. A total of 508 sites in Africa were tested to determine if they satisfied some or all of these criteria. The homoclime areas so defined were compared with reports summarising the results of extensive trials of *E. citriodora* in Africa. The conclusion drawn from this test was that the Bioclimate Prediction System will assist in the selection of suitable species for evaluation where trials have not already been carried out.

INTRODUCTION

Recently developed interpolation techniques have greatly improved the accuracy with which mean climatic factors can be predicted at sites remote from recording stations (Wahba and Wendelberger, 1980; Hutchinson and Bischof, 1983; Hutchinson et al., 1984). This paper demonstrates how a new method for analysing the climate of a species’ natural distribution (Nix, Busby and Hutchinson, in prep.) can be used to assist in selecting overseas locations suitable for trials. *Eucalyptus citriodora* Hook., chosen for this demonstration, is native to north-eastern Australia (Boland et al., 1984) and the method was used to indicate areas where this species would be worthy of trial in Africa. As this species has already been widely tried in Africa the advantages and limitations of the method could be assessed.

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Climate has for many years been an important criterion for selecting species for trial. General reviews, such as those by Troup (1932) and Streets (1962), have included descriptions of the climatic requirements of many species. The importance of climate continues to be recognised in recently developed computer accessible compendia of species characteristics (Webb et al., 1980; Hackett and Carolane, 1982).

Considering the eucalypts as a particular example, Metro (1955), Turnbull and Pryor (1978) and Jacobs (1981) have provided summaries of climatic requirements based on knowledge of natural distribution alone or together with experience from trials outside the natural range. Several countries with a special interest in establishing eucalypts have carried out detailed studies of climatic conditions. Most notable has been the work in Brazil and South Africa which has been summarised by Jacobs (1981). In both countries, maps showing areas with similar climatic conditions (Poynton, 1971: Instituto Brasileiro de Desenvolvimento Forestal, 1977) were developed from analyses based on water balance calculations (Thornthwaite, 1948; Thornthwaite and Mather, 1955). These maps have been used as a basis for establishing field trials and selecting species for planting.

Whilst Brazil, South Africa and many other countries have largely determined the species they require for plantation forestry, there is a major need in many countries for species for fuelwood and agroforestry use. Many potentially useful species have not been tested in these countries (Boland and Turnbull, 1981). There is a need for a method to assist in defining climatic environments where these species would be worth testing.

The work described here is part of a program co-ordinated by the CSIRO Division of Forest Research and funded by the Australian Centre for International Agricultural Research. Two of the main aims of the program are to identify Australian trees of potential value for agroforestry and fuelwood production, and to define environments in which these species can be successfully grown overseas.

The Bioclimate Prediction System to be demonstrated was originally developed by Nix(a), Busby(b) and Hutchinson(a) [(a) CSIRO Division of Water and Land Resources, (b) Bureau of Flora and Fauna] to analyse the distribution of individual taxa or aggregations of taxa within Australia. A major objective of the method was to suggest limits for species whose distributions were imperfectly known. However, the potential of the method to assist in identifying homoclines for the introduction of species within and between other countries has been recognised by the authors from the outset. The method has already been used to identify areas within Australia suitable for commercial cultivation of Australian wildflowers (Mackenzie and Nix, 1982). This paper describes one of the first applications of the method to identify suitable overseas environments for Australian species.

Method

The technique used involves four major stages:
1. Geocoding of distribution
2. Estimation of climatic data at specified locations
3. Estimation of the 'climatic profile' for the selected species
4. Identification of homocline sites within the potential area for planting.

The first stage involves the identification of a number of specific locations where the selected species occurs. The locations should as far as possible represent the range of climatic environments within the natural distribution.

In the case of *E. citriodora* it was possible to take advantage of the 'EUCALIST' computer data file of herbaria records which describes the natural range of over 500 eucalypt taxa (Chippendale and Wolf, 1984). When a small number of duplicates and records for cultivated specimens had been removed, there were 84 records for
E. citriodora. Each record included a location described as latitude and longitude in degrees and minutes. About one quarter of the samples also recorded the elevation from which the sample had been taken. However, in the majority of cases it was necessary to estimate elevations from 1:100 000 scale maps using the latitude, longitude and brief location descriptions as a guide. Estimated elevations were recorded to the nearest 10 m. The locations of the 84 sites are shown in Figure 1. (All figures were plotted using the MAPROJ program described by Hutchinson, 1981).

The next two stages of the technique were dealt with by the BIOCLIM program package, which was designed to implement the Bioclimate Prediction System. Complete details of the package are presented by Nix, Busby and Hutchinson (in prep.). Briefly, latitude, longitude and elevation data for the 84 locations were read in by the program. The program accessed data describing surfaces of monthly mean values for daily maximum temperature, daily minimum temperature and precipitation. These surfaces have been derived from analyses of data from several thousand meteorological stations across Australia. The mean errors associated with predicting climatic values were estimated by generalised cross-validation (Wahba and Weinberger, 1980). For the continental surfaces used to estimate minimum and maximum temperatures these errors were 4.1 and 1.3% respectively. For the north-eastern and central Queensland regional precipitation surfaces mean errors were 13.1 and 9.9% respectively.

The BIOCLIM program interrogated the surfaces to determine 36 monthly values of maximum temperature, minimum temperature and precipitation for each of the 84
locations. From these 36 values the program calculated for each site 12 climatic variables which have been found to be of value in defining climatic environments:

1. annual mean temperature
2. minimum temperature of the coldest month
3. maximum temperature of the hottest month
4. annual temperature range (3–2)
5. mean temperature of the wettest quarter (3 months)
6. mean temperature of the driest quarter
7. annual mean precipitation
8. precipitation of the wettest month
9. precipitation of the driest month
10. annual precipitation range
11. precipitation of the wettest quarter
12. precipitation of the driest quarter

For each of the 12 variables listed above the BIOCLIM program calculated information summarising the variation in climatic conditions. For example, from the 84 values of annual mean temperature (°C) BIOCLIM calculated the following values:

Mean 20.94
S.D. 1.06
Minimum value 18.52
5 percentile 19.52
25 percentile 20.27
50 percentile 20.88
75 percentile 21.54
95 percentile 22.71
Maximum value 24.09

Maximum and minimum values for all 12 variables are shown in Table 1. These values, which defined the climatic profile of the natural distribution, were used in the final stage to identify homoclimes. Other values, such as the 5 and 95 percentile measures could be used to provide more closely limited homoclimes if desired.

<table>
<thead>
<tr>
<th>BIOCLIM variable No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min.</td>
<td>18.5</td>
<td>3.5</td>
<td>28.0</td>
<td>18.5</td>
<td>22.5</td>
<td>14.0</td>
</tr>
<tr>
<td>Max.</td>
<td>24.1</td>
<td>12.9</td>
<td>35.6</td>
<td>29.2</td>
<td>27.4</td>
<td>20.7</td>
</tr>
<tr>
<td>Min.</td>
<td>349.2</td>
<td>93.4</td>
<td>0.0</td>
<td>71.8</td>
<td>246.9</td>
<td>0.0</td>
</tr>
<tr>
<td>Max.</td>
<td>1928.9</td>
<td>434.3</td>
<td>51.6</td>
<td>402.9</td>
<td>1126.5</td>
<td>189.1</td>
</tr>
</tbody>
</table>

Meteorological data for 508 locations in Africa (Figure 2) were available from the GLOCLIMEAN data base (Nix, McMahon and Hutchinson, in prep.). These data were based mainly on the stations included in the Meteorological Office (1967) publication ‘Tables of Temperature, Relative Humidity and Precipitation for the World Part IV’, together with additional data for southern Africa. The 12 BIOCLIM parameters listed above were calculated for each station.
A program was written to read the data defining the climatic profile of the species being considered (see Table 1). The program then checked each parameter to see if the climatic value for the particular location was within the bounds defined. 1 or 0 was used to indicate the success or failure to satisfy each parameter. If a location satisfied all 12 parameters it was given a suitability rating of 1. This indicated the locations in Africa with the most similar climates to those of *E. citriodora*’s native range.

Experience with other species (Nix, pers. comm.) suggests that plants may adapt to different climatic conditions provided that mean annual temperature, minimum temperature of the coldest month, mean annual precipitation and precipitation of the driest quarter are within the bounds to which they are adapted. Locations which satisfied these criteria (BIOCLIM parameters no. 1, 2, 7 and 12), but failed on other factors were rated as 2. Locations which failed on any of these factors were rated 0 to indicate that they were unlikely to be suitable for *E. citriodora* planting.

For example, the computer output provided the following type of information for each location:

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>400001</td>
<td>Mbala</td>
<td>-8.85</td>
<td>31.33</td>
<td>1673</td>
</tr>
</tbody>
</table>

**BIOCLIM PARAMETERS**

<table>
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<th>1</th>
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<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.6</td>
<td>10.6</td>
<td>28.3</td>
<td>17.7</td>
<td>19.6</td>
<td>18.1</td>
<td>1155.6</td>
<td>238.8</td>
<td>0.0</td>
<td>238.8</td>
<td>645.2</td>
<td>5.0</td>
</tr>
</tbody>
</table>

**Suitability**  
**BIOCLIM success/fail**  
2  
111001111111
The identifying number and name of the station were given, along with its location in decimal degrees (negative values indicating stations in the southern or western hemispheres) and its elevation in metres. All 12 BIOCLIM parameters were printed by the program for each station. The 1s and 0s under 'BIOCLIM success/fail' indicated which of the 12 parameters were satisfied. For the example above, parameters 4 and 5 were outside the defined bounds given in Table 1. Parameter 4 (annual temperature range) was 17.7 and parameter 5 (mean temperature of the wettest quarter) was 19.6 at Mbala. In a similar way, it was possible to examine the result for any of the 508 stations to see not only how they were classified, but also why they were classified in a particular group.

Although it did not satisfy all the BIOCLIM parameters, Mbala's climatic values did fall within the range of parameters 1, 2, 7 and 12. It was therefore given a suitability rating of 2. The locations of all meteorological stations given ratings of 1 or 2 are shown in Figure 3.

To assess the usefulness of the climatic profile as a basis for selecting species for trials, the homoclimes shown in Figure 3 were compared with summarised results for *E. citriodora* in the countries concerned. Jacobs (1981) reviewed results from eucalypt trials using data collected from 32 African countries. He noted that *E. citriodora* was grown in plantations in Angola, Madagascar, Mozambique, Zimbabwe, South Africa and Malawi. With the exception of Malawi, all these countries contained type 1 homoclimate locations satisfying all 12 BIOCLIM parameters. Figure 3 shows several type 2 locations in Malawi, as well as type 1 locations at Fort Jameson and Chipata, just across the border in Zambia.

Zambia and Namibia were the only countries containing type 1 locations which Jacobs (1981) did not mention as having established *E. citriodora* plantations. Recent trials of *E. citriodora* in Zambia at Chisamba and Chati have shown good growth, but poor form (Piearce, pers. comm.). Poynton (1979) reported that *E. citriodora* has been tried at Kavango and Owambo in Namibia (South West Africa). A severe drought killed all the trees at Kavango, but various provenances are still growing at Owambo, though no details of performance were given.

Poynton (1979) also described *E. citriodora* trials in South Africa in detail. He concentrated his discussion on northern Transvaal, eastern Transvaal and Zululand. These areas are represented in Figure 3 by locations such as Louis Trichardt, Barberton and Melmoth. Poynton (1979), also reported some initial success from the arboretum at Fort Cunynghame in south-eastern Cape Province. The two southernmost sites in Figure 3, East London and Bashee, are in this region. According to Poynton (1979) 'results elsewhere have been very poor'.

Jacobs (1981) reported that Rwanda, Kenya, Nigeria and Sudan had promising trials of *E. citriodora*. 'Fine results' were obtained in Rwanda and Figure 3 indicates a type 2 location in this relatively small country. Growth of 19 m in 19 years had been obtained in an experimental plantation at Muguga in Kenya. Muguga was not included in the data set, but several sites in Kenya came close to selection as type 2 locations. For example, Nairobi only failed on parameter 1 (mean annual temperature) with a value of 17.9 compared with the defined range of 18.5–24.1. In Nigeria, *E. citriodora* has provided encouraging results on the Jos Plateau (Kemp, 1970). The town of Jos was included in the data set and narrowly missed inclusion in Figure 3 as parameter 2 (minimum temperature of the coldest month) was 13.9 compared to a maximum defined value of 12.9. Jacobs (1981) stated that *E. citriodora* had grown well in the Nuba Mountains in Sudan. The nearest location included in the data was Kadugli, which clearly failed on parameters 1 (27.1) and 2 (15.0). However, it is likely that climatic conditions in the mountains are considerably cooler than at Kadugli, which has an elevation of only 500 m.
Jacobs (1981) reported poor results from *E. citriodora* trials in Morocco and Zaire. Figure 3 shows one type 2 location at Larache in Morocco and recent information from there indicates that *E. citriodora* has been successful in at least two arboreta near Ben Slimane and Souk el Arbaâ. (Tamri, pers. comm.) Larache is the closest location to Souk el Arbaâ included in the GLOCLIMEAN data set. Figure 3 shows two type 2 homocline locations in Zaire and though *E. citriodora* performed poorly in trials on 'infertile, acid sandy soils near Kinshasa', it 'grows well as an ornamental tree in the city' according to Jacobs (1981).

In his brief review Jacobs (1981) made no mention of *E. citriodora* trials or plantations in Algeria, Cameroon, Chad, Congo, Egypt, Ethiopia, Ghana, Ivory Coast, Lesotho, Libya, Mali, Niger, Senegal, Swaziland, Tunisia, Uganda or Upper Volta, though he did summarise results with other eucalypts in these countries. Figure 3 shows no homocline locations in 12 of these 17 countries. Single homocline locations are shown in Cameroon, Libya, Swaziland and Uganda. The isolated location in Cameroon shown in Figure 3 is N’Gaoundere. This is a high elevation (1,101 m) position experiencing similar climatic conditions to the Jos Plateau area in Nigeria, where *E. citriodora* has proved successful (Kemp, 1970). Poynton (1979) reported that trees of *E. citriodora* 'grew fairly well' reaching 37 m in about 25 years at one unnamed site in Swaziland. Trials in Uganda have shown *E. citriodora* to be successful on relatively high elevation and high rainfall sites (Kriek, 1970). Three type 2 homocline locations were also shown in Ethiopia, as well as a single location in Somalia, but no additional information has been obtained for this region. A type 2 location was also shown in Botswana. Poynton (1979) noted that *E. citriodora* had been successfully grown in trials at altitudes of 900–1,200 m and in areas with mean annual rainfall of about 500 mm. The location indicated in Figure 3 is Maun, which is situated at an elevation of 945 m and has a mean annual rainfall of 465 mm.

**Discussion**

This demonstration of the Bioclimatic Prediction System produced encouraging results. The type 1 locations indicated most of the countries in which *E. citriodora* is a significant plantation species and the type 2 locations indicated most countries where it has been considered to be worthy of trial.

The results certainly warrant a more detailed evaluation of the method involving more species and specific locations. It is intended to evaluate 12 other eucalypts; *E. cladocalyx*, *E. fastigata*, *E. globulus* spp. *globulus*, *E. gomphocephala*, *E. grandis*, *E. maculata*, *E. paniculata*, *E. regnans*, *E. resinifera*, *E. robusta*, *E. sideroxylon* and tropical sources of *E. tereticornis*. These come from a range of environments in Australia, include species with extensive as well as limited ranges, and have all been extensively tested in Africa.

It is intended to collect data on performance in arboreta, so that predictions for specific locations can be evaluated. Researchers having information on trials in Africa can obtain a simple one-page form from the author if they wish to contribute information. The form requests information similar to that tabulated by Poynton (1979) i.e. site name, latitude, longitude, elevation, estimated mean annual rainfall, comments on soil conditions (if known), and for each species an assessment of general performance (successful/marginal/failed/not tried). If the information is available, space is provided for data on age, stocking, mean d.b.h., mean height and general comments on health, form and if appropriate, reasons for failure.

Failures can be as useful as successes in building up a picture of a species requirements. Reports often naturally concentrate on successes, but failures may be very informative, especially if the reason for failure can be identified.
The results presented here were particularly intriguing as *E. citriodora* was described by Jacobs (1981) as an 'adaptable' species. It has been found to be successful in areas which experience more severe drought conditions and different seasonality of rainfall (i.e. summer drought) than in its native range. The problem of adaptability can be a problem in developing predictions of climatic suitability based solely on native distribution. Natural distribution provides an indication of ecological niche; the physiological niche may be different.

However, the ability of *E. citriodora* to adapt to zones other than its natural range did not appear to limit the usefulness of the analysis presented here. The type 2 locations provided an apparently effective indication of *E. citriodora*'s adaptability. Some of the other species to be tested (e.g. *E. regnans* and *E. resinifera*) are described by Jacobs (1981) as having 'comparatively little adaptability', so it will be interesting to test the BIOCLIM method with these species.

If results from trials in countries or regions outside the natural range already exist these can be incorporated in the construction of a climatic profile, provided accurate estimates of parameters can be obtained for the sites. However, the objective here was to test the effectiveness of a method based on natural distribution alone.

The BIOCLIM analysis only considers macro-climate; other factors, such as soil conditions and topography must be suitable for a species to be successful. Methods such as those described by Austin *et al.* (1984) may offer means to assist in selecting suitable species for particular slope, aspect and soil conditions when planning at the meso-scale. However, they require more data collection than the Bioclimte Prediction System and interpreting the effects of parent material on soil fertility may be difficult if the method is applied to other countries.

In the present case, where about 100 Australian species are being considered for use overseas, the homocline approach offers an appropriate first step in species selection. It is hoped that it will eventually be possible to incorporate climatic profiles and maps, such as are shown in Table 1 and Figure 3, into a compendium similar to that of Webb *et al.* (1980). This compendium would describe Australian species with potential for agroforestry and fuelwood production. Foresters faced with selecting a few little-known species for trial should find this information of considerable assistance.

**Acknowledgements**

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June McMahon for providing data from the GLOCLIMEAN data base.


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TO STOP THE YELLOW DRAGON WITH A GREEN OCEAN

By Hong Guang LAI *

SUMMARY
Twenty-five years of experience in attempting to cultivate the south-west fringes of the Gobi Desert has shown the benefit of fostering the indigenous vegetation in conjunction with shrub and tree shelter belts. An agriculturally based community of 26,000 people now flourishes in an area which was previously inhospitable and virtually uninhabited.

RéSUMÉ
25 ans d’expérience à essayer de cultiver les bords sud-ouest du désert Gobi a montré l’avantage de nourrir la végétation indigène de concert avec les arbustes et des arbres. Aujourd’hui, une communauté fondée sur l’agricole prospère dans une étendue préalablement inhospitalière et presque inhabitéée.

RESUMEN
Viente y cinco años de experiencia intentando cultivar las franjas del suroeste del Desierto Gobi han demostrado la ventaja de promover la vegetación indígena en unión con arbustos y cortinas rompevientos. Una comunidad agrícola conformada de 26,000 personas disfruta de condiciones estables en un área que era previamente inhospitable y virtualmente inhabitable.

Introduction
This article is a digest of the progress report, written in Chinese, of the Agricultural Division of the Regiment in Xinjiang where the expansion of the Gobi Desert has been halted and the provision of shelter and irrigation has enabled a community to establish a viable agricultural enterprise.

Location and Climate
The Mosowan Reclamation Area is at latitude 44° 48’ N and longitude 86° 06’ to 86° 24’ E to the north of Shihezi City, Xinjiang, on the southern border of the Dzungarian Basin. (Roughly 2,500 miles west of Vladivostok and 1,200 miles north of Kathmandu.) At the northern foot of the Tienshan Mountains and an elevation of 346 to 358 m, the

*Agronomist, State Farm 150, Shihezi, Xinjiang, People’s Republic of China.
sand dunes of the Ku-Erh-Pan-Tung-Ku-Te Desert threaten to encroach from three sides. The continental climate has temperatures down to $-42.8^\circ C$ and as high as $43.1^\circ C$ with an annual average of just over $6^\circ C$, frozen soil for 124 days a year and 166 days free from frost. The rainfall is 117 mm, 84 mm of which falls between the warmer months of April to October. The annual average relative humidity is 61% and the potential evaporation is 16 times the rainfall. Additional water is available for irrigation from the Manasi River and from the melting snows on the Tienshan Mountains. The water table before significant irrigation commenced in 1965 was around a depth of 13 m. It rose by 50 cm a year to a depth of 8–10 m but the rate of increase has now reduced to about 5 cm a year, giving a depth of 7–9 m. The prevailing and damaging wind is from the north-west and can exceed the force of a fresh gale 5 to 25 times a year and can be worse than a strong breeze, 40 times a year. The average windspeed is 1.9 m/second.

Development

Since the project started in 1958, 16,667 ha of waste land has been reclaimed from the desert. The area now planted annually for agriculture is 11,000 ha with an annual production of 12,500 T of grain, 2,500 T of cotton, 5,000 T of vegetable oil and 323 T of meat and a wide range of fruit and vegetables. Some 80 km of roads have been built and 700 km of canal. Trees are planted alongside both the roads and canals as well as around some 40 residential areas and in a system of shelter belts. Timber from these belts has produced 90% of the wood used in construction providing 384,000 m$^2$ of floor space. It has also been used in making furniture, weaving, for tool handles, for canal revetment, for fire-wood and for building the winter quarters for livestock. The older tree belts offer shelter and grazing for 20,000 lambs. There are 26,000 people on the project with 10,200 working in agriculture and in industrial projects such as an integrated grain and oil processing factory, in two cotton processing factories, in building and
machinery maintenance and in service occupations. There are 38 specialised production brigades each with its own primary school, shopping facilities and clinic with one major hospital for the project area and six secondary schools. The agricultural equipment includes 113 big and medium tractors and 18 combine harvesters.

The Benefits of Shelter

The original policy in 1958 was to clear the existing scrub, practise agriculture with the support of irrigation and plant tree belts within the farm area. In the first nine years, 1,666 ha was planted as shelter; of this 75% was satisfactory. A further 248 ha was established during the next nine years. Some of the most damaging winds are experienced during May. In 1961, an 8-hour gale on 31 May devastated over 20% of the annual crop. On 25 May, 1974 an 8-hour gale was seen to cause over twice as much damage to crops in the exposed north-west sector compared with those benefiting from established tree shelter. A gale on 21 May, 1983, comparable with that of 1961, killed 50% of the cotton which abutted directly on to sand dunes but the effect of the established tree and shrub belts limited the overall farm losses to only 1%. As an example, Cotton Strip No. 58, protected by a belt 12 m wide and 12 m high suffered no irreparable damage up to 84 m from the belt but 30% damage 144 m from the belt. A belt of trees 4 to 6 trees wide at a stocking referred to as 30% will reduce wind speed at a point 20 times the tree height, down wind, by 24% and up to 40% closer to the belt. A belt, 2 to 4 trees wide at 50% stocking will give comparable wind speed reductions of 20% and 35%.

In 1974 it was decided that an overall shelter policy should be implemented. In the most exposed north-west section an outer area would be designated a conservation zone, 22 km long and 3 km wide, placed along a north east, south west axis. The collection of plants, even dead ones would be prohibited and grazing forbidden. Wardens and security staff can impose penalties which discourage transgression. The second line of defence would be a tree belt 25 km long and 20 to 30 m wide. In addition, a web of tree planting within the agricultural area would give tree belts every 150 to 250 m at right angles to the north-west wind supported by north-west, south-east belts every 800 to 1,000 m. By 1983 the outer area had been enclosed, 150 ha had been planted along the second line and over 67 ha of the internal web were being planted annually. The standing volume of timber after 24 years is 80,000 m³. Production of grain per ha for the 1978–82 period was 70% higher than for 1959–63 and for cotton, 37% higher. Total meat production has shown a tenfold increase comparing the two periods.

It is already possible to perceive differences in characteristics of the vegetation in the unconserved and conserved localities and to monitor the associated changes in microclimate. A typical unconserved 100 m² of desert would contain 23 shrubs with an average height of 17.5 cm and stem diameter of 1.6 cm giving a vegetational cover of 4%. A similar conserved area would have 31 shrubs averaging 47.2 cm in height with average diameters of 2 cm with the vegetation covering 8%. The conserved area will
enjoy a reduction in wind speed of 20–40%, a reduction in potential evaporation of 10–15%, an average reduction in air temperature of between 0.1 and 0.2°C and an increase in relative humidity of between 2 and 2.5%. Parts of the conserved area have been further improved with shrub planting to give a 37.5% vegetation cover. When this area is compared with the unconserved region, the increase in vegetational cover is associated with a reduction of wind speed by 40–60%, in potential evaporation by 25–30%, in air temperature by 0.1–0.5°C and an increase in relative humidity by 3.6–4.4%. The effect of the husbandry on the climate towards the centre of the oasis when compared with exposed locations shows a 1°C drop in temperature, an increase in rainfall of 8.3 mm, an increase in snowfall of 8.9 mm and whilst the desert will be subjected to 19 days a year with wind speeds over 17 m/second, within the cultivated area there will only be 3 such days.

Choice of Species

Planting is carried out up to 100 km into the desert. Pioneer species must be able to cope with extremes of temperature, drought and exposure, being engulfed by blown alkaline sand with a possible high salt content. *Haloxylon ammodendron* (C. Mey) Bge will reach a height of 5 m in 8 years. *Tamarix ramosissima* Ledeb is showing promise and growing at 1 m a year and is prolific and widely distributed in the deserts of north west China. *Haloxylon persicum* Bge ex Bois. & Buhse occurs locally in the Dzugarian Basin and copes well with difficult conditions. *Calligonum leucocladum* (Schrenk) Bge is another local species which can be used on stable or semi-stable dunes and in three years has reached 1 m in height and a stem diameter of 1.7 cm.

The main species used for internal shelter belts is *Populus nigra* L. cv. Afghanica (Dode) Bean. It reaches 8–10 m in 5–6 years and quickly contributes shelter as a wind break. It has a narrow crown, with a minimum adverse effect on the farming, and a straight
stem which can produce saw timber in 10 years. White elm, *Ulmus pumila* L., tolerates cold, drought, poor fertility, salt and alkali soils and is free from disease. It is used for 20% of the shelter belts. A recently introduced Henan white elm is fast growing, reaching 6 m in two years, is straight boled, the diameter breast height after two years being 6 cm. The third most important shelter belt species is *Elaeagnus angustifolia* L. It can cope with the adverse conditions, has a straight stem and is used for intercropping with the poplar.

**Establishment**

Some of the original failure can be attributed to a combination of incorrect timing, inappropriate species, inadequate watering and irregular planting bed, a surfeit of unremoved alkali soil and poor nursery stock. It has been shown that the preparation of the planting hole by creating a depression 30–50 cm deep and level will increase survival by 17–20% and better use is made of available irrigation. There are 27 local nurseries providing planting stock for specific areas of responsibility and three large production nurseries. In the conservation zone, *Haloxylon ammodendron* will produce a 2 m² crown in 4–5 years, 8 m² crown in 8 years and 10 m² crown in 10 years. There is an incentive to provide vegetational cover quickly, but the area is 66 km². The compromise has been a 4 m × 4 m spacing.

Tree belts are planted 20 m to 30 m wide using 4–6 rows of trees or where single rows of poplar are used along canal sides a 1 m spacing is employed. The fields are irrigated 4 or 5 times during the growing season which also supplies adequate water for the trees. They shade the exposed water surface and although they occupy land, the strips, 5–9 m, each side of canals can suffer high salt concentrations. This salination is not observed beneath the trees. Single rows of poplar at 1 m spacing in plot 42, No. 12 Company, planted in 1980 had reached 7.68 m and 7 cm DBH by July, 1983. An 8-year old, canal
bank mixture of poplar and elm had the respective measurements of 9.5 m and 6 m height with diameter breast height of 10 cm and 9 cm.

**Moving Sand**

Wind blown, dark alkali sand causes problems over 90% of the cultivated area. Crops can be abraided or engulfed with sand. It is important to level dunes which form and each winter several thousand dunes involving over 9M m$^3$ of sand are redistributed at a rate of 270 m$^3$/ha. Subsequent crops show the benefit of this redistributed sand with gains of up to 40% for grain and 10% for cotton. The soil structure is improved with increased porosity of up to 10%, the salt concentration on the surface 10 cm is lowered by 0.7%, soil moisture increased by 3.5% and soil temperature of the surface 5 cm increased by 3–3.6°C.

**Agricultural Crop Rotation**

It is important to limit the contiguous areas of exposed soil. Individual field size is restricted to 16–26 ha. Every year about 2,000 ha is planted with lucerne. The 2,500 T of high quality dry fodder produced is winter feed for the stock housed on 131,000 m$^2$ of covered area. After three years of lucerne, the land is ploughed for grain for one or two years. The crop for the subsequent year is cotton. The resultant benefit from the lucerne boosts grain production by 20–40% and cotton by 5–9%.

**Conclusion**

A thriving agricultural and forestry enterprise has been established in daunting desert conditions. The land-locked nature of the Dzungarian Basin causes the rising water table
to be a subject of concern, as is the raising of salt concentrations associated with irrigation
and evaporation. During the period of the Cultural Revolution, farm production figures
dropped until in the late 1960s and early 1970s the whole project was making a financial
loss. The recovery of co-operation and enthusiasm since 1976 has produced a 45% improvement in grain yields per ha and 80% increases in cotton yields per ha. In addition
to a beneficial moderation of the local climate, the whole project is developing the
infrastructure of the region and showing a profitable return on turnover of 6.6%.

Acknowledgements
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on behalf of all the workers in the Regiment.
The photographs were taken by W. Y. Zhang and J. J. Wang of the Institute of
Environmental Protection, Shihezi, Xinjiang.
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AGROFORESTRY AS AN AID TO RATIONAL RURAL DEVELOPMENT IN VANUATU

By P. E. NEIL and P. A. JACOVELLI*

SUMMARY

Vanuatu is a small Pacific island nation with over 80% of its population rural based and dependent on subsistence agriculture. One of the few natural resources is the land which thus forms the basis of national development. Agriculture and forestry have been given priority. The rapid expansion of forestry development in recent years has led to difficulties over land acquisition. All land is customary owned and lease agreements with the local landowners must be obtained.

Concern of the landowners over the loss of land for future subsistence gardening prompted the Forest Service to initiate demonstration/trial agroforestry plots. To date, mainly subsistence crops have been grown between lines of Cordia alliodora, the principal forest tree species. Work has also been initiated on growing cash crops (cocoa, coffee) within the forestry plantations. This agroforestry approach is in accordance with the Government's development policy and appears to offer more rational and optimum use of the country's limited land resources.

C. alliodora is well known in agroforestry combinations elsewhere. However, the need for research in other potentially important forest tree species in agroforestry associations is recognised and discussed. The potential benefits of this approach in Vanuatu and in other countries, where conditions may be comparable, are seen as considerable.

INTRODUCTION

Over 80% of Vanuatu's 130,000 people (1983 estimate) live in rural areas and depend on subsistence agriculture for their livelihood. Rural development, which aims to improve the quality of life for these people, has been a Government priority since the country (formerly the New Hebrides) gained independence from Great Britain and France in 1980.
The country consists of an irregular ‘Y’-shaped chain of some eighty islands stretching for more than 800 kilometres in the S.W. Pacific Ocean (Figure 1). Nearly 90% of the total land area (11,800 km$^2$) is covered by the ten largest islands which are mountainous and covered in either natural rain forest or secondary bush. Vanuatu has very little in the way of natural resources apart from its land. Fortunately, much of this land is highly fertile and it was soon recognised that land would have to form the basis of any economic development.

Consequently, the first 5-year National Development Plan (Anon. 1982) for 1982–86, emphasised that the way to economic self-reliance lay through increased food production. This involves growing sufficient crops to meet everybody’s needs and to replacing costly (and often less nutritious) imports, as well as growing cash crops to earn foreign exchange and to generate national wealth to enable the country to fund future development.

Fig. 1. Map showing the main islands of Vanuatu and the relation of the country to other Pacific countries.
AGROFORESTRY IN VANUATU

Agriculture And Forestry

In accordance with the Development Plan, major cocoa and coffee development projects have been initiated as joint venture enterprises between the Government, the Commonwealth Development Corporation and local landowners. Also, a large cattle development project is soon to start on Espiritu Santo.

Forestry development to produce high quality timber for export and for local needs has also been given high priority by the Government. The natural forest resource in Vanuatu is generally very poor in valuable timber trees, which are widely scattered thus making logging an expensive operation. Consequently, forestry development has been largely with exotics.

Following a number of species trials established in the early 1970s, *Cordia alliodora* emerged as the most promising species for the wetter sites, whilst *Pinus caribaea* var. *hondurensis* proved to be well suited to the drier southern islands (Neil, 1983). Once suitable species had been identified, a number of small-scale (5-10 ha) ‘Local Supply Plantations’ (LSPs) were established on various islands. More recently, however, larger, export-orientated ‘Industrial Forest Plantations’ (IFPs) have been established, for example, on Aneityum, Erromango, and Pentecost.

It should be emphasised that most of the land on which forest development is occurring is very fertile, hence the success of *C. alliodora* which is known to be a rather demanding species. In other countries such land would normally be utilised for agricultural development.

The rapid expansion from LSPs to IFPs, some of which involves planting up to 200 ha per year on one site, is not without its problems, of which land is often foremost.

Land Issues

When Vanuatu gained independence, the new Constitution decreed that all land revert to its indigenous owners (apart from land the Government sees fit to acquire in the public interest). This marked a turn-around in policy following a long period since the mid-nineteenth century when most of the ‘best’ land (i.e. accessible coastal areas generally) had been gradually alienated particularly for coconut plantations, first by missionaries and small traders, but later by much larger concerns. Such dealings were often unscrupulous, showing little or no respect for the customary significance of land in Vanuatu.

Custom issues tend often to be considered a constraint on development because of their apparent resistance to accept change. However, it is Government policy to see ‘custom’ and the traditional ways used as a force for development. Custom is dynamic and in the words of the Prime Minister, ‘There is no reason why it should not continue to change and adapt itself as it obviously has done in the past’ (Lini, 1980).

It soon becomes evident to anyone dealing with land-related issues that ‘land has values which transcend issues of use and property’ (Lane, 1971). Land is of fundamental importance in Melanesian culture — an importance which is often difficult for ‘outsiders’ to fully appreciate. ‘... custom land is not only the site of production, but it is the mainstay of a vision of the world. Land is at the heart of the operation of the cultural system. It represents life, materially and spiritually’ (Bonnemaison, 1984).

The land tenure pattern in Vanuatu is no easier to understand. In brief, land is generally held in common ownership by clans, there being no individual ownership as such.
Boundaries are often ill-defined, due to the oral tradition of land ownership declining with increasing Western influence.

Rural development inevitably disrupts this traditional land tenure system, although since Independence, the customary values have been given priority. Before any forestry development takes place now, the customary landowners of the land in question must first be identified and permission obtained for the use of their land for tree planting. It is important to note that the land always belongs to the custom landowners who retain the right to use the land as they wish, provided that no damage is done to the trees. A lease must be drawn up which is acceptable to the landowners and the Government. Whilst this is undoubtedly a fair system, ensuring that any rural development has the full backing of the landowners, it usually involves a great amount of time and effort in securing such agreements.

All forestry development in Vanuatu thus depends completely on extension work to obtain sufficient land for plantations. With the small LSPs, a verbal agreement from the landowners was generally sufficient. However, forestry in this country has recently come of age and larger scale plantations currently being established require considerable amounts of land. Obviously, these IFPs were sited on islands where there is little population pressure and adequate areas of suitable land. Even so, the protracted procedure for obtaining land agreements has meant in the past that plantations have been started on some islands without all the land needed to economically justify such projects being leased.

PENTECOST — A Case Study

As a prime example of the land problems forestry faces in Vanuatu, the Pentecost IFP will be briefly outlined.

The IFP was started in mid-1983, the original project proposal calling for some 7,000 ha of land to be planted with *C. alliodora*. However, despite early enthusiasm for the project by landowners, requests for additional areas of land for forestry have met with some reluctance on the part of the landowners. Many meetings and conversations with the local people have revealed that their main concern is a worry over the loss of possible future garden areas. As population pressure is minimal in the proposed project area, undoubtedly, there are other issues involved. For example, the difficulty in comprehending something as new and the long-term nature of forestry development, as well as intangible traditional concepts regarding land use.

This is where the idea originated that an approach more sympathetic to their traditional land use patterns — particularly subsistence gardening — would help alleviate their worries over leasing land for forestry by demonstrating that forestry and agriculture can work together.

Current silviculture of *C. alliodora* is to cut 10 m lines through the natural bush poisoning, frill girdling, burning or felling the remaining unwanted trees to gradually open the canopy. Stumps of *C. alliodora* will then be planted at 2.5 m intervals in each line, which are regularly weeded (Hudson, 1984; Neil, 1984A).

Agroforestry demonstration plots and trials have been established in between the lines of *C. alliodora*. These have concentrated on local subsistence crops which would traditionally be grown in ‘gardens’ created during shifting cultivation operations. Root crops, especially yam, taro, manioc and sweet potato are the staple food of Ni-Vanuatu and thus are the main garden crops. Other crops frequently planted include ‘island cabbage’, sugar cane, bananas and pawpaw. Table 1 lists the common subsistence crops grown in Vanuatu.
Table 1
Common Subsistence Crops of Vanuatu

<table>
<thead>
<tr>
<th>Crop</th>
<th>Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>TARO</td>
<td>ISLAND TARO</td>
</tr>
<tr>
<td>FIJI TARO</td>
<td>(Xanthosoma spp.)</td>
</tr>
<tr>
<td>WATER TARO</td>
<td>(Cyrtosperma chamissonis)</td>
</tr>
<tr>
<td>GIANT TARO/NAVIA</td>
<td>(Alocasia macrorrhiza)</td>
</tr>
<tr>
<td>YAM</td>
<td>(Dioscorea spp.)</td>
</tr>
<tr>
<td>MANIOC/CASSAVA</td>
<td>(Manihot esculenta)</td>
</tr>
<tr>
<td>KUMALA/SWEET POTATO</td>
<td>(Ipomoea batatas)</td>
</tr>
<tr>
<td>ISLAND CABBAGE</td>
<td>(Abelmoschus manihot)</td>
</tr>
<tr>
<td>SUGAR CANE</td>
<td>(Saccharum spp.)</td>
</tr>
<tr>
<td>CORN/MAIZE</td>
<td>(Zea mays)</td>
</tr>
<tr>
<td>KAVA</td>
<td>(Piper methysticum)*</td>
</tr>
<tr>
<td>BANANA</td>
<td>(Musa spp.)</td>
</tr>
<tr>
<td>PAW-PAW/PAPAYA</td>
<td>(Carica papaya)</td>
</tr>
<tr>
<td>PINEAPPLE</td>
<td>(Ananas comosus)</td>
</tr>
<tr>
<td>PUMPKINS, MELONS, etc.</td>
<td>(Cucurbita spp.)</td>
</tr>
<tr>
<td>COCONUTS</td>
<td>(Cocos nucifera)**</td>
</tr>
<tr>
<td>LAP-LAP</td>
<td>(Meliconia spp.)</td>
</tr>
</tbody>
</table>

+ beans, cabbages, etc.

* Kava is also a cash crop on a limited scale.
** Coconuts, as well as being the most important export product, are consumed locally and can thus be considered a subsistence crop.

Note: Where markets are close by (e.g. Port Vila and Luganville), these subsistence crops are sold. In most of Vanuatu, however, the markets for such perishable food crops are extremely limited.

Kava (*Piper methysticum*), too, is commonly found in gardens, the roots of which are used to prepare a traditional custom drink — an integral part of the Melanesian cultural heritage.

The custom practices of planting these crops were followed at all times to enhance the demonstration value of the plots and to show that traditional methods are still applicable in an agroforestry situation.

The following demonstration/trial plots have been established in one year old *C. alliodora* plantations:
- a typical ‘Pentecost garden’ with a mixture of virtually all the common subsistence crops;
- a trial with eight varieties of sweet potato;
- a manioc/cassava trial (6 varieties) Plate 1;
- a taro trial (3 species/13 varieties);
- a yam trial (12 varieties);
- a plot of kava;
- trials with coffee (arabica and robusta), cocoa and cardamon are in preparation.

In other *C. alliodora* plantations on Pentecost, kava and taro are being successfully grown between lines of three year old *C. alliodora*.

Initial findings show that there is no apparent reduction in yield of these crops and no interference with the trees under such conditions. From these early results a general set of guidelines as well as notes on specific crops have been drawn up (Jacovelli & Neil, 1984).
Plate 1. Two varieties of manioc (*Manihot esculenta*) planted in the inter-rows between the lines of *Cordia alliodora* (4–5 months old) on Pentecost Island.

Plate 2. Plots of kava, *Piper methysticum* (foreground), and manioc, *Manihot esculenta* (rear), either side of a row of *C. alliodora*. 
Another example of agroforestry within the current forestry programme includes cattle grazing under both *C. alliodora* and *P. caribaea* in LSPs and IFPs on various islands (Erromango, Aneityum, Pentecost, Espiritu Santo).

**Other Agroforestry Possibilities**

The acceptance by the customary landowners of the combination of subsistence gardening and forest plantations is a first step in encouraging the expansion of forest development. An obvious next step would be to encourage the establishment of cash crops between the lines of trees, which would offer earlier returns to the landowner and should contribute to the national economy.

This is in accordance with the Government’s policy within the National Development Plan and would appear to offer a more rational and optimum use of the limited land resource that Vanuatu has available for its development. The Forest Service is at present establishing trials with coffee and cocoa under *C. alliodora*.

**C. alliodora In The Agroforestry Situation**

*C. alliodora* is well known in agroforestry elsewhere (Johnson & Morales, 1972; Combe & Budowski, 1979; Beer, 1981) as it is well suited to such associations. It is a strong light demander which can be grown in an open situation and yet form a straight, self-pruned trunk. Despite having a fairly dense crown when young, as the trees get older, the crown becomes thinner, thus producing some shade, but still allowing light to reach the ground. Generally, the bark of *C. alliodora* appears to be unpalatable to cattle and assuming the trees are old enough to withstand trampling, receive no damage when plantations are grazed.

Despite the apparent suitability of *C. alliodora* to conditions in Vanuatu and our agroforestry work, the limitations of using only one tree species at one spacing (10 m × 2.5 m) are recognised. A number of problems are now emerging with the species. On some sites, it has not performed as well as originally expected and also may be severely attacked by a root rot, *Phellinus noxius* (Neil, 1984, in press). Also, under certain conditions, *C. alliodora* forms a large lateral root system which may compete with the roots of agricultural crops.

Hence it is important to consider other possible forest tree species that could be used in place of *C. alliodora*.

Species such as —

*Terminalia brassii,*
*T. calamansanii,*
*Eucalyptus deglupta,*
*Swietenia macrophylla,*
*Toona australis* and
*Cedrela odorata*

have all shown promise in species trials. As yet none have been tested in the agroforestry situation in Vanuatu, but if one or more should become important from a forest point of view, then they should be incorporated into the agroforestry research programme. Likewise, the effect of espacement should also be considered with these species and *C. alliodora* too. The spacing of a forest plantation has a direct relationship on the time taken to achieve canopy closure. This in turn directly affects the kind of crops that can be incorporated into an agroforestry system.
Conclusion

The agroforestry work being conducted by the Vanuatu Forest Service at present should go some way towards alleviating the landowners' fears, even though there is little or no population pressure (as yet) on much of the land concerned. Population pressures are inevitably going to increase rapidly with an annual growth rate of 3.2%. However, agroforestry as defined by the demonstrations and trials on Pentecost should help to promote a more rational approach to land use in the rural development of Vanuatu. However, besides the demonstration value of the agroforestry on Pentecost, the potential benefits of such an approach for elsewhere, where conditions may be comparable, are seen as considerable.

Acknowledgements

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REFERENCES


LESOTHO WOODLOT PROJECT, PINUS RADIATA NURSERY NUTRITION EXPERIMENT

By K. F. RICHARDSON and R. W. PERKINS*

SUMMARY
An experiment with P. radiata using seven nursery soils, three fertiliser and two irrigation treatments was conducted in the 1983/84 season after attempts to reduce chlorosis had proved ineffective. All measured parameters varied widely for different soils. Chlorosis was worst in those of pH greater than seven. Acidification of irrigation water reduced survival and exacerbated chlorosis but did not affect height growth. Fertilisation decreased the numbers of survivors but increased the height of those that did, reducing chlorosis except in soils of pH > 7. Soil and foliar analyses did not reveal the cause of chlorosis. Treatments are recommended for each nursery.

RÉSUMÉ
Pendant la saison 1983/84, au a conduit une expérience avec P. radiata, en employant sept sols de pépinière, trois fertilisateurs et deux traitements d’irrigation, après l’insuccès des essais de réduire la chlorose. Toutes les paramètres mesurés ont beaucoup varié dans les sols différents. La quantité la plus grande de chlorose se trouvait à ceux qui avaient le pH de plus de sept. L’acidification de l’eau d’irrigation a réduit la survivance et a exacerbé la chlorose, mais elle n’a pas altéré la croissance de hauteur. La fertilisation a amoindri le nombre de ceux qui ont survit mais elle en a fait aggrandi la hauteur, tout en réduisant la chlorose, sauf dans les sols de PH > 7. L’analyse du sol et l’analyse du feuillage n’a pas dévoilé la cause de la chlorose. Les traitements pour chaque pépinière sont recommandés.

RESUMEN
Un experimento con Pinus radiata usando siete suelos en el vivero, tres fertilizantes y dos condiciones de riego fue conducido durante el período de crecimiento 1983/84 después de que varios intentos de reducir clorosis demostraron ser inefectivos. Todas las variables medidas variaron grandemente para los diferentes suelos. La clorosis fue peor en aquellos con pH mayor de siete. Acidificación del agua del riego redujo la sobreviviencia y empeoró la clorosis pero no afectó el crecimiento en altura. La fertilización redujo el número de sobrevivientes pero incrementó la altura de estos y la clorosis se redujo excepto en suelos con pH > 7. Análisis del suelo y foliar no reveló las causas de clorosis. Tratamientos son recomendados para cada vivero.

Introduction
Up to 1973 a relatively large proportion of the seedlings produced in Lesotho’s forest nurseries were of conifers, mostly pines. Basic techniques for raising this type of plant were poorly recorded and only one surviving document includes a section on these (Marwick, 1970). From 1973, when the Lesotho Woodlot Project took over the existing nurseries, the numbers of conifers raised each year were sharply reduced in favour of eucalypts. By 1980 only a few thousand seedlings of Pinus radiata (D. Don) and

*Lesotho Woodlot Project, PO Box 774, Maseru 100, Lesotho.
*P. pinaster* (Ait.) could be found in nurseries. Within the next two years, however, changing policy on species choice produced a huge increase in demand for conifer seedlings, especially *P. radiata*. By 1984/5 demand exceeded 1,25 million, a figure which may well double within 2 or 3 years.

In 1980/81 when *P. radiata* was included in various nursery experiments, an unexplained yellowing — or chlorosis — of growing tips was noticed in plants being raised in soil-filled plastic sleeves. Later, some deaths were observed apparently as a result of severe chlorosis. It was also recorded that chlorosis was most prevalent in sleeves of narrow diameter (Richardson & Powell, 1981a) and when seedlings were growing in soil mixed with poorly decomposed compost (Richardson & Powell, 1981b). In 1982 foliage samples were collected from yellow and green *P. radiata* seedlings growing in soil-filled sleeves and also from seedlings grown in a peat-based medium in planter flats. Analysis of these samples revealed that the only difference between the yellow and green sleeve plants was that the former had a 20% greater content of Calcium and contained only two thirds as much Manganese. When compared with the very healthy planter flat trees, both types of sleeve tree looked very inferior and in the analyses it was found that the planter flat trees had a very low level of Calcium (half that of the green sleeve trees) and a far superior Nitrogen to Phosphorus ratio — 7:1 as opposed to 3.5:1 for the sleeve trees. This poorer ratio was produced by low Nitrogen levels rather than high Phosphorus. From these results it was deduced that acidification was required to counteract high Calcium levels and additional Nitrogen was required.

Despite fertilisation and acidification of irrigation water the problem of chlorosis persisted and was soon observed in most of Lesotho’s lowland nurseries. However, it was also noticed that *P. halepensis* (Mill.) and *Cupressus glabra* (Sudw.) displayed no chlorosis symptoms whatsoever whilst *P. radiata* growing alongside them was severely affected. Similarly, *P. pinaster* was heavily chlorotic, often more so than *P. radiata*. It was known that many of the soils used in nurseries were of relatively high pH and the differential occurrence of chlorosis between conifer species was put down to their varying tolerance of this. Again, acidification was instituted but no beneficial result was obtained.

The chlorosis story was further complicated by the occurrence of this phenomenon in some years and not in others and, when it did occur, it could appear at any time and did not seem to coincide with any particular season or stage of plant growth.

By 1983 it was common to see whole beds of yellow-tipped conifer seedlings in nurseries and, although any growth loss associated with chlorosis could be tolerated, the knowledge that plant death could also occur prompted the establishment of an experiment to try to identify the cause of chlorosis.

**Experimental Treatments and Design**

Three factors were thought to be potentially responsible for causing chlorosis. Soil type was almost certainly involved because chlorosis had been seen to vary in intensity from nursery to nursery; acidity of irrigation water was still thought to be particularly important because *P. radiata* is a notorious calcifuge and many nursery water supplies were known to be of high pH; fertilisation was expected to be important for obvious reasons. As vigorously growing mature pines are found at or near all the nurseries, mycorrhiza were not thought to be lacking.

It was decided to test as many nursery soils as possible in factorial combination with standard and acidified irrigation water and three fertiliser treatments at the Maseru nursery.

In August and September, 1983 six lowland nurseries were visited and supplies of
nursery soils were collected ex-nursery or from source. At the same time small samples of soil were taken for analysis and water samples were collected for pH testing.

In late September seven soils typical of those used at six nurseries were used to fill black polyethylene sleeves each with a capacity of 300 ml. With the quantities of soil available each soil type was eventually represented in the experiment by 600 sleeves. The sleeves were arranged in plots of 50 (5 x 10) on the research terrace of the Maseru nursery in a randomised layout divided into two replications (blocks).

The seven soils were allocated the following code digits:

0 Maseru  
1 Leribe  
2 Mohale’s Hoek  
3 Quthing  
4 Mafeteng(1)  
5 Mafeteng(2)  
6 Butha-Buthe

The following treatments were to be applied in all possible combinations:

| WATER  | 0 | Unacidified town supply (pH 6.8 to 7.2)  
| FERTILISER | 0 | No fertiliser  
| 1 | Acidified with hydrochloric acid (pH 3 to 4)  
| 1 | 3:1:5(38) Soluble @ 14 g/plot/week in solution  
| 2 | 3:2:1(25) Granular @ 7 g/plot/week as top dressing

This gives a total of 42 treatments (7 soils x 2 waters x 3 fertilisers) with each treatment identified by three digits. For example: 010 is Maseru soil receiving acidified water and no fertiliser.

Sowing and Maintenance

At the beginning of November, 1983 all sleeves were sown at 2 seeds/sleeve with stratified seed of *P. radiata* of local origin. Germination was poor, maintenance of germination conditions by watering and shading was neglected by unsupervised but relatively senior staff and damping-off and cutworm damage was allowed to develop without preventative treatment. By mid-December, stocking rates were so low that remaining seedlings were removed and, at the end of the month, the experiment was re-sown at 3 seeds/sleeve using a different source of local seed. This time strict attention was paid to proper watering, shading and application of chemicals to control damping-off fungi and cutworms. Germination started within 7 days and after 18 days a first pricking-out was made to single out multiple germinants within sleeves and to put a seedling in those sleeves which contained no germinants. This movement of seedlings was done only within treatment plots. Thirty-two days after sowing a second pricking-out was done — there had been further germination and some deaths — and this time distribution of excess seedlings was carried out within and between plots of the same soil within each of the two replications.

Watering and fertilisation treatments began immediately after the second pricking-out and continued until the end of April — 17 weeks after sowing. Acidified water was applied only on weekdays; all plots received normal water at weekends. Fertilisers were applied as a single weekly dose and where 3:1:5(38) was applied in water solution an equal amount of water was applied to other plots.

During its life the experiment was weeded twice (by hand) and also received two root-prunings.
On 27 April the experiment was closed when the tallest trees had reached a height suitable for field planting — about 17 cm.

Assessments and Foliage Sampling

Germination was assessed at 18 days and after 32 days the number of sleeves with a plant was recorded. At 10½ and at 17 weeks survival, height and yellowing were assessed. Heights were deduced from a 40% random sample within plots at the earlier date and a 100% assessment was made at the second date. Yellowing was scored for individual trees in a 100% sample at both dates using the following scale:

0  No yellowing
1  Some signs of yellowing
2  Pronounced yellowing
3  Severe yellowing

At 17 weeks the leading shoots (12 to 15 mm) of every seedling in the experiment were cut off, bulked up in 7 lots according to soil, oven-dried to constant weight at 70°C and sent to UK for analysis. At the same time the soil samples collected on visits to nurseries in 1983 were also dispatched for analysis having been oven-dried in readiness.

Because of the limited amounts of soils that had been procured and used in the experiment there was not enough foliage material from individual treatment plots to allow analysis on a treatment basis. By the close of the experiment it was obvious that soils had the greatest effect on height growth and yellowing and the decision was taken to bulk up the limited samples on this basis.

Results

Survival at 32 days

After two pricking-outs and re-distribution of plants including the disposal to waste of excess germinants where germination had been good, there was a large variation in seedling counts between soils — water and fertiliser treatments had not yet begun:

<table>
<thead>
<tr>
<th>Soil Source</th>
<th>Percentage of Sleeves with a Seedling</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Maseru</td>
<td>86.2</td>
</tr>
<tr>
<td>1 Leribe</td>
<td>96.3</td>
</tr>
<tr>
<td>2 Mohale's Hoek</td>
<td>100</td>
</tr>
<tr>
<td>3 Quthing</td>
<td>93.7</td>
</tr>
<tr>
<td>4 Mafeteng(1)</td>
<td>46.8</td>
</tr>
<tr>
<td>5 Mafeteng(2)</td>
<td>99.2</td>
</tr>
<tr>
<td>6 Butha-Buthe</td>
<td>99.7</td>
</tr>
</tbody>
</table>

Survival, Height and Yellowing at 10½ Weeks

By this time survival was also being influenced by the water and fertiliser treatments. Acidified water reduced survival by an average of 11% over the whole experiment and, also on average, the soluble and granular fertilisers gave a survival reduction of 28% and 9% respectively. There were various effects of interactions between treatments; these became more obvious later on and are presented for the 17 week assessment in the next section.
Yellowing at 10½ weeks was worst in the Quthing soil and relatively severe in the Mafeteng(2) soil. Least chlorosis occurred in the Leribe soil. Height was affected by various treatments and this intensified later on (see below).

Table 2
Survival, Height and Yellowing at 17 Weeks

<table>
<thead>
<tr>
<th>Soil</th>
<th>TREATMENT</th>
<th>SURVIVAL (%)</th>
<th>HEIGHT (mm)</th>
<th>YELLOWING Score</th>
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</thead>
<tbody>
<tr>
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<td>0</td>
<td>68</td>
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<td>55</td>
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<td>1</td>
<td>62</td>
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</tbody>
</table>

Least Significant Difference @ 95%: 35.5, 28.1, 1.1
The following figures illustrate the results obtained at 17 weeks. Their significance is demonstrated in the analyses contained in the Appendix.

![Fig. 1. Effects of soil at 17 weeks.](image)

![Fig. 2. Yellowing.](image)
Fig. 3. Effects of fertiliser at 17 weeks.

Fig. 4. Effects of water at 17 weeks.
In the table below are given the best treatments for each soil:

**Table 3**
Effects of Treatment Interactions at 17 weeks

<table>
<thead>
<tr>
<th>Soil</th>
<th>Best overall</th>
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<tbody>
<tr>
<td>Leribe</td>
<td>Ordin. Water No fert.</td>
</tr>
<tr>
<td>M/Hoek</td>
<td>Ordin. Water No fert.</td>
</tr>
<tr>
<td>Quthing</td>
<td>Ordin. Water 3:2:1(25) or: Acid Water No fert.</td>
</tr>
<tr>
<td>Mafeteng(2)</td>
<td>Ordin. Water No fert.</td>
</tr>
</tbody>
</table>

**Table 4**
Results of Foliage Analyses

<table>
<thead>
<tr>
<th>Element</th>
<th>Maseru</th>
<th>Leribe</th>
<th>M/Hoek</th>
<th>Quthing</th>
<th>Maf(1)</th>
<th>Maf(2)</th>
<th>B-Buthe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (% )</td>
<td>3.02</td>
<td>2.62</td>
<td>2.63</td>
<td>2.65</td>
<td>2.48</td>
<td>2.79</td>
<td>2.78</td>
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<tr>
<td>Phosphorus (%)</td>
<td>0.374</td>
<td>0.275</td>
<td>0.297</td>
<td>0.302</td>
<td>0.290</td>
<td>0.359</td>
<td>0.317</td>
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<td>Potassium (%)</td>
<td>1.40</td>
<td>1.42</td>
<td>1.39</td>
<td>1.91</td>
<td>1.45</td>
<td>1.86</td>
<td>1.25</td>
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<tr>
<td>Magnesium (%)</td>
<td>0.171</td>
<td>0.128</td>
<td>0.166</td>
<td>0.114</td>
<td>0.157</td>
<td>0.127</td>
<td>0.182</td>
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<td>Calcium (%)</td>
<td>0.28</td>
<td>0.26</td>
<td>0.28</td>
<td>0.58</td>
<td>0.41</td>
<td>0.17</td>
<td>0.35</td>
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<tr>
<td>Copper (ppm)</td>
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<td>5</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Manganese (ppm)</td>
<td>91</td>
<td>100</td>
<td>87</td>
<td>38</td>
<td>80</td>
<td>216</td>
<td>79</td>
</tr>
<tr>
<td>Zinc (ppm)</td>
<td>105</td>
<td>122</td>
<td>111</td>
<td>120</td>
<td>111</td>
<td>161</td>
<td>121</td>
</tr>
<tr>
<td>Iron (ppm)</td>
<td>61</td>
<td>61</td>
<td>61</td>
<td>55</td>
<td>70</td>
<td>67</td>
<td>84</td>
</tr>
<tr>
<td>Aluminium (ppm)</td>
<td>32</td>
<td>67</td>
<td>21</td>
<td>41</td>
<td>47</td>
<td>54</td>
<td>43</td>
</tr>
<tr>
<td>Boron (ppm)</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>17</td>
<td>19</td>
<td>21</td>
<td>16</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Nitrogen/Phosphorus ratio</th>
<th>8.07</th>
<th>9.53</th>
<th>8.86</th>
<th>8.77</th>
<th>8.55</th>
<th>7.77</th>
<th>8.77</th>
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<tbody>
<tr>
<td>Seedling Surv. (%)</td>
<td>48.2</td>
<td>58.3</td>
<td>73.0</td>
<td>41.5</td>
<td>18.8</td>
<td>45.2</td>
<td>55.5</td>
</tr>
<tr>
<td>Ranking</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Seedling Ht. (mm)</td>
<td>145</td>
<td>156</td>
<td>161</td>
<td>123</td>
<td>109</td>
<td>126</td>
<td>128</td>
</tr>
<tr>
<td>Ranking</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Seedling Yellowing (%)</td>
<td>0.42</td>
<td>0.42</td>
<td>0.75</td>
<td>2.92</td>
<td>1.42</td>
<td>1.75</td>
<td>0.58</td>
</tr>
<tr>
<td>Ranking</td>
<td>1=</td>
<td>1=</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>3</td>
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Table 5
Critical foliar nutrient levels for evaluating the nutrient status of *Pinus radiata* nursery crops in New Zealand (Knight 1978)

<table>
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<th>Nutrient</th>
<th>Approximate lower end of sufficiency range</th>
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<tbody>
<tr>
<td>Nitrogen</td>
<td>(%) 1.4–1.6</td>
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<tr>
<td>Phosphorus</td>
<td>(%) 0.12–0.14</td>
</tr>
<tr>
<td>Potassium</td>
<td>(%) c. 0.35</td>
</tr>
<tr>
<td>Magnesium</td>
<td>(%) 0.06–0.08</td>
</tr>
<tr>
<td>Calcium</td>
<td>(%) c 0.10</td>
</tr>
<tr>
<td>Copper</td>
<td>(ppm) 2–3</td>
</tr>
<tr>
<td>Manganese</td>
<td>(ppm) 5–14</td>
</tr>
<tr>
<td>Zinc</td>
<td>(ppm) 5–10</td>
</tr>
<tr>
<td>Iron</td>
<td>(ppm) 25–40</td>
</tr>
<tr>
<td>Boron</td>
<td>(ppm) c 8</td>
</tr>
<tr>
<td>N/P ratio</td>
<td>~ 10</td>
</tr>
</tbody>
</table>

Barring the N/P ratio all the elements for which foliar analyses were carried out are in considerable surplus.

Table 7
Results of Water pH Tests

Most nurseries have more than one supply source for irrigation water. The usual primary source for each nursery is marked with an asterisk in the table below:

**MASERU**
- pH Direct town supply 6.7
- *Town supply via concrete dam 7.8
- Earth dam supply 7.9

**LERIBE**
- *Earth dam supply 5.8 Two primary sources commonly used in mixture. Earth dam supply usu.
- Direct town supply 6.1
- *Iron dam (variable mix of those above) 6.4 used for sleeve trees

**MOHALE’S HOEK**
- Direct town supply 7.2
- *Earth dam supply 8.6
- Above from taps in nursery 7.4

**QUTHING**
- Earth dam (sample from nursery tap) 6.8

**MAFETENG**
- Town supply (sample from concrete collection tank) 6.7 Both sources now superseded by
- *Earth dam supply 6.8 borehole supply

**BUTHA-BUTHE**
- Direct town supply 6.7
Table 6
Results of Soil Analyses

<table>
<thead>
<tr>
<th></th>
<th>Maseru</th>
<th>Leribe</th>
<th>M/Hoek</th>
<th>Q'ing</th>
<th>Maf(1)</th>
<th>Maf(2)</th>
<th>BButhe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture % o.d.s.</td>
<td>1.9</td>
<td>0.0</td>
<td>3.0</td>
<td>1.5</td>
<td>1.6</td>
<td>0.3</td>
<td>2.0</td>
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<tr>
<td>W/V ratio g/cm³ a.d.s.</td>
<td>1.26</td>
<td>1.20</td>
<td>1.04</td>
<td>1.06</td>
<td>1.20</td>
<td>1.26</td>
<td>1.36</td>
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<tr>
<td>pH</td>
<td>6.9</td>
<td>5.6</td>
<td>6.2</td>
<td>7.3</td>
<td>7.6</td>
<td>5.7</td>
<td>7.0</td>
</tr>
<tr>
<td>E.C. ms/cm 1:5 H₂O</td>
<td>0.10</td>
<td>0.13</td>
<td>0.19</td>
<td>0.26</td>
<td>0.23</td>
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<tr>
<td>Calcium Carbonate</td>
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<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Soluble Cations Na</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>me/100 g a.d.s. K</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>0.0</td>
<td>0.1</td>
<td>0.0</td>
<td>0.6</td>
<td>0.0</td>
<td>0.1</td>
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<tr>
<td>Cations K</td>
<td>0.3</td>
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<td>0.5</td>
<td>0.7</td>
<td>0.3</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>me/100 g a.d.s. Mg</td>
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<td>0.8</td>
<td>9.3</td>
<td>2.3</td>
<td>3.4</td>
<td>0.6</td>
<td>5.7</td>
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<td>11.3</td>
<td>1.9</td>
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<td>10.9</td>
<td>1.3</td>
<td>13.0</td>
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<td>T.E.B. me/100 g a.d.s.</td>
<td>17.8</td>
<td>2.9</td>
<td>28.9</td>
<td>35.7</td>
<td>15.2</td>
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<td>19.0</td>
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<td>C.E.C. me/100 g a.d.s.</td>
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<td>5.0</td>
<td>30.3</td>
<td>22.4</td>
<td>11.9</td>
<td>3.0</td>
<td>18.4</td>
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<td>Total N %</td>
<td>0.04</td>
<td>0.09</td>
<td>0.17</td>
<td>0.19</td>
<td>0.05</td>
<td>0.04</td>
<td>0.04</td>
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<td>Organic C %</td>
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<td>2.23</td>
<td>2.43</td>
<td>0.36</td>
<td>0.40</td>
<td>0.38</td>
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<tr>
<td>Exchangeable Al me/100 g a.d.s.</td>
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<td>0.7</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
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<tr>
<td>Loss on ignition %</td>
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<td>Available P (Olsen) ppm</td>
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<td>6</td>
<td>11</td>
<td>23</td>
<td>6</td>
<td>3</td>
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<td>K</td>
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<td>3</td>
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<td>15</td>
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<td>27</td>
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<td>28</td>
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<td>31</td>
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<td>8</td>
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<td>(Dry mineral soil)</td>
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<td>5</td>
<td>9</td>
<td>17</td>
<td>13</td>
<td>11</td>
<td>4</td>
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Discussion of the Results

Examination of the results does not reveal the cause of chlorosis. It does, however, provide some hints as well as useful information on the effects of treatments on seedling survival and height:

The best plants were produced by the Leribe and Mohale’s Hoek soils whilst the worst were produced by the Mafeteng(1) and Quthing soils. Both the latter are of high pH (>7) and are high in Sodium and Calcium respectively. The poor quality of the Mafeteng soil was recognised when it was sampled and the second Mafeteng source was immediately recommended as replacement.
Acidification of irrigation water was generally detrimental especially when it was combined with fertiliser applications. Overall, acid water reduced survival by 13%, increased yellowing by a third and left height unaffected. Only for the Quthing and Mafeteng soils was acid of some slight benefit. Even in these cases its usefulness is outweighed by the relative difficulty of acidifying water supplies.

Fertilisers at the levels used in the experiment depressed survival, particularly in the case of 3:1:5(38). Sometimes, 3:2:1(25) gave an increase in survival and generally there was a height increase due to fertilisation.

In Table 3 are listed the best treatment combinations for survival, height and yellowing in the seven soils. Where 2 or more water/fertiliser combinations produced the same effect involving the least input is given. The last column gives the best overall treatment combination for each soil with survival being given a high priority.

It is encouraging that fertilisation completely eliminated chlorosis in seedlings grown in Maseru soil whilst for the Leribe, Mohale's Hoek, Mafeteng(2) and Butha-Buthe soils one or both fertilisers reduced it. In the high pH Quthing and Mafeteng soils they increased it.

The results are confounded by three factors:
(i) The experiment was subject to the prevailing environment of the Maseru nursery. This differs from that of other nurseries in many ways, some unquantifiable, others unrecognised. Water pH (see Table 7) is an identifiable source of variation.
(ii) As recorded in the introduction, yellowing comes and goes for no apparent reason; perhaps this experiment would have yielded very different results if conducted in a different year.
(iii) Soils used in the experiment may not be truly representative of those used in nurseries although every effort was made to ensure that they were. Soil collection sites definitely vary from year to year and even within one season. Some nurseries still include an element of compost in their soil; this would have a profound effect on seedlings.

Soil and foliage analyses have been examined by specialists who can find no underlying trend which points to the cause of chlorosis. All the seedlings had N/P ratios far superior to those recorded for similar plants in previous years (see introduction) and only the high Calcium content of seedlings grown in Quthing soil provides a hint as to the cause of yellowing. Work by Nakos (1978) reveals that lime-induced chlorosis of Pinus radiata has occurred in Greece. There appear to be many similarities between his findings and ours. Nakos found intensity of chlorosis to be related to high HCO₃ concentrations and excessive soil moisture. He finds support for a hypothesis of ‘competitive chelation’ whereby a portion of the Fe in plant leaves is inactivated. This is due either to the presence of other metals competing with Fe or inorganic ions competing with physiological sites for the Fe within the plant. It is obvious that high pH soils should be avoided as should the sodic duplexes (Mafeteng(1)).

Conclusions

This experiment raised more questions than it answered. Certainly, the major cause of chlorosis in pine seedlings cannot be deduced. There are, however, indications that high soil pH and high Calcium levels in the soil are involved. Acidification of water to counteract these factors was only minimally effective. Mostly, acidification increased yellowing and mortality. Fertilisers were applied at rates generally detrimental to survival, but they tended to compensate for this by increasing height growth and eliminating or reducing chlorosis. A reduction in the symptoms of chlorosis was often, but not always, accompanied by an increase in height — the effect of fertilisation on both variables.
The different soils produced markedly different survival and growth of seedlings and, for each soil — assuming the tested soils are still in use in nurseries — a best combination of water and fertiliser treatments can be deduced. Application of these will probably be of benefit until further information comes to hand.

**Recommendations**

Without firm conclusions about the causes of chlorosis — and indeed about its real importance — the only recommendation that can be made to enhance the survival and growth of *P. radiata* seedlings is that the best combinations given in Table 3 be employed until further notice. This recommendation supersedes any interim recommendations already notified. It is important that nurserymen observe the effects which treatment produces and they should report back through D.F.Os.

It is obvious that the soil used at Quthing is very poor for *P. radiata*. Unless a more suitable soil can be introduced, this nursery should not raise large numbers of this species. It should, rather, adhere to its current policy of concentrating on the more tolerant *P. halepensis*.

The easiest recommendation to make is that chlorosis and associated growth loss (if any) and death should be investigated much more intensively. This experiment showed up very large differences in seedling survival — due mostly to different soils — and this aspect of pine culture should also be investigated. This is of particular importance in the light of rapidly increasing demand for seedlings and a restricted seed supply. Further research should be conducted as the major effort of one graduate who should have easy access to literature and other researchers with knowledge of tree seedling nutrition. Experiments should be carried out with several soils at each nursery. The ultimate aim would be to find a soil which gives good survival and growth (and low chlorosis) without the need for repetitive or complicated nursery treatments. Pot trials with wheat or vegetables may provide useful short-cuts as they have done in nutrition research in other southern African nurseries.

Included in further work should be investigations of the effects of Iron and Sulphur.

**Acknowledgements**

The authors would like to thank Dr F. Rooyani of the Lesotho Agricultural College and Dr B. Badamchian of the Soils Laboratory (Min. of Agric. Research Division) for their help with the interpretation of the soil and foliage analysis results.

**REFERENCES**


APPENDIX
ANALYSIS OF VARIANCE OF THE RESULTS

A. Survival

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B. Height

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C. Yellowing

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### CHI-SQD FACTORIAL ANALYSIS OF SURVIVAL

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*sig. @95%  **sig. @ 97.5%  ***sig. @ 99%

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When the founders of classical economics decreed that the three factors of production are land, capital and labour, they created two centuries of problems for forest economists, since trees do not fit neatly into this scheme. Generations of accountants and taxation theorists have failed to find satisfactory solutions for forest investment, with consequent confusion in the framing of forest policy. For a long time it seemed that there was widespread consensus in favour of state forestry, but the current debate in Britain and the USA throws the door open wide to alternative possibilities.

Roger Sedjo, whose own book on the comparative economics of plantation forestry offers a valuable world-wide view of investment, has now edited this symposium on policy in the USA. It is drawn from a meeting held in Denver in January 1983. The book is divided into four parts entitled 'Investment in Resources', 'The Transitory Nature of the Land Base', 'Strategies of Investment' and 'Effects of Public Policy'. Sedjo's introduction gives a useful summary.

Part One sets the scene by relating forestry to the wider questions of resource economics. W. W. Rostow uses the theory of the Kondratieff Cycle to suggest that the coming decades will be a period of rising resource prices with consequent advantages for investment in forestry. Charles Bingham looks at world markets and finds reasons for cautious optimism about timber, concluding that there should be more investment in the best US sites.

Part Two is by far the longest section, though by no means the most interesting. Thomas Waggener develops a complex marginal analysis and applies it to the competition with agriculture. At still greater length, Donald Miller and Robert Rose study the relatively localised phenomenon of urban expansion at the expense of forests, concluding in favour of strict land use controls. Finally A. Alan Dyer and W. E. Frayer look in more practical detail at the loss of forest land to farming, finding that the greatest single cause is the expansion of soybean cultivation. Thus the demand of Europe for pork and chicken presses as surely on the forests of the USA as that of the USA for beef does on those of Latin America.

Part Three opens with a chapter by James G. Yoho on the economics of private investment. Then Marion Clawson renews his criticism of federal forest management, proposing a new system of leasing state land to large timber corporations — with a 'pullback' mechanism to enable smaller non-commercial bodies to save large areas for other purposes. The debate is taken up by Douglas MacCleery, who maintains that most of the faults found by Clawson are in the process of being corrected.

Part Four consists of a single chapter by Dennis Teeguarden on the effect of public policy on public and private investment. He considers various alternatives to State forestry, including privatisation, Clawson's leases and his own proposal for the establishment of public corporations to manage and exploit federal forests. On the private front he gives a useful summary of the incentives available to private investors.

This is a useful and timely book, adding a North American perspective to the growing worldwide debate on forest resources. We may not be much nearer to fitting trees into classical economics, but at least there are some new ideas on forest policy.

Philip J. Stewart


This book attempts to cover both the growing and the harvesting and utilisation of Eucalypts for industrial wood within a single volume. It is a second printing containing as many 'minor improvements and corrections as possible throughout the text', without being a complete revision of the book.
The concentration is mainly on Eucalypts likely to be useful for high production plantations in Australia in competition with *Pinus radiata*.

Chapters include: Choice of species and seed sources, forest areas and centres of forest industry, stand establishment, protection from grazing disease and fire, stand management, yield statistics, harvesting, nine chapters on utilisation, economic considerations, social and environmental implications and future trends, contributed by 33 authors.

Although a sizeable book the width of coverage has resulted in some of the subjects being dealt with fairly superficially but there is a vast amount of useful information not only for Australian use but also for use by those who grow Eucalypts elsewhere in the world. Chapter 4 on stand establishment is a particularly useful one giving information on the ecology and biology of Eucalypts in a concise but readable and very informative form. Chapter 3 gives information on forest areas based on 1971 figures. Although the reasons for this are explained in the preface more up to date figures would have been preferable. The map showing the production forest regions is small and poorly produced on the rear cover and is almost indecipherable to any without the eyesight of a hawk.

The chapters on utilisation give a comprehensive general coverage of wood properties and utilisation. Perhaps not enough is made of the part that appearance plays in the use of wood for decorative uses and the advantages this may give to Eucalypts over the pines. Little is also said about the possibilities of breeding for such things as greater production, less tension and spring, better drying properties and other beneficial properties.

These criticisms are, however, small in relation to the general value of the book as a general reference work on the major Eucalypt species. Of particular interest to the forester growing Eucalypts outside Australia is that it gives an account of the ecology and methods of growth and regeneration of the trees in their natural environment which should help him to make fewer mistakes than he would otherwise make.

The book is, therefore, a very useful general compendium of useful information on the Eucalypts as grown and used in Australia which few who work with Eucalypts should be without.

R. A. Plumptre

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The exploitation, management and conservation of the native beech (*Nothofagus*) forests of New Zealand are the subject of some controversy. When controversy rages, it is hard to obtain facts. This has been particularly true in the debate on the beech forests and the publication some time ago, by Friends of the Earth, of the quaintly titled 'Rush to Destruction' (Searle, 1975) did little to clarify the position. In the midst of this hysteria, and prompted by it, comes a new and authoritative work by John Wardle, a forest ecologist at the NZ Forest Research Institute.

The author attempts, with some success, to cover everything that might be pertinent to the genus *Nothofagus* in New Zealand. He opens with an initial chapter giving the characteristics of the genus and the particular details of the New Zealand species. The following chapters are then grouped into four: Part 1 covers the distribution and composition of the forests in both North Island and South Island, Part 2 is devoted to the physical and biotic factors in the beech dominated ecosystems, Part 3 gives the life history of the trees and Part 4 covers utilisation and management. All fourteen chapters are lavishly illustrated with maps, diagrams, tables and plates. A few of the latter are in colour but most are in black and white. The printing and quality of paper are excellent, which prompts questions over the rather poor contrast of many of the black and white plates.

In the opening chapter on the distribution of the genus the author discusses not only the present situation through Australasia and South America but also gives a review of the considerable fossil evidence, a fascinating insight despite the eventual conclusion that none of the theories on the origin and direction of dispersal are totally acceptable. In discussing the distribution of the species, New Zealand is divided into some 33 zones and each described separately, so providing an immensely valuable record of the present status of the beech forests, but not casual reading. Interest is revived, however, with the subsequent section on classification and on the variations encountered with changes in altitude, rainfall, latitude and soil. This theme is continued in Part 2 with a discussion of the
effects of man's activity, climate, vulcanism, fire, wind, snow, etc. Insects are well covered but perhaps of greater value to readers from outside New Zealand is the chapter on wild mammals. The influence of introduced animals, notably brush-tailed possums and red deer, on the indigenous flora and fauna is of particular interest.

As with so much of the book, the description of the life history of the beeches that forms Part 3, draws extensively not only on published material but also on a wealth of hitherto unpublished work by the author and his colleagues.

The final part sets out, perhaps somewhat belatedly, the extent of the resource. New Zealand has 6.25 million ha of indigenous forest of which two-thirds are classified as protection forests and only 13 per cent is virgin production forest. The latter may seem a small percentage but it represents a greater area than that occupied by Pinus radiata plantations in neighbouring Australia. Because of the availability of the more easily worked native softwood, exploitation of the beech forests developed slowly; a factor that, as A. Kirkland points out in his foreword, probably explains why this resource still remains intact. The timbers of the five New Zealand beeches, however, have particular features that suit them to a range of uses, particularly where a decorative finish is required. Unfortunately the extent of butt rot and the poor form of many stems considerably depress the conversion rate in comparison to other species. The book closes with a review of the non-timber values of the beech forests, including animal products and honey as well as protection and amenity.

The coverage of this book is so wide that the reader is constantly expecting the quality to drop, marking the interchange from the author's speciality to simple review. There are occasional lapses, such as persisting with the outmoded term 'recretion' for crown leaching when reproducing the results of R. B. Miller's classic studies of nutrient cycling in hard beech. However, the quality never really falls below excellent, whether dealing with the taxonomy of the genera, the birds of the forests or the seasoning characteristics of the timber. It is a scholarly work and the author is to be congratulated. Well written, although not a casual read, one would expect it to become a standard reference work within New Zealand. Its relevance elsewhere is necessarily much reduced but even there it should interest not only those research workers concerned with the genus Nothofagus but also those interested in forest ecology generally.

Professor H. G. Miller
Head of Department of Forestry,
University of Aberdeen.

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Conference Report

In September, some 200 foresters from 31 countries assembled at Victoria on Vancouver Island for a very full programme of papers on the theme of forest investment. The opening address by Sir Peter Marshall, KCMG (Deputy Commonwealth Secretary-General) was followed by the address on the theme of the conference by The Honourable Donald S. Macdonald, (Chairman of the Royal Commission on the economic union and development prospects for Canada).

The subject of investment was presented under three headings — 'The challenge – the case for investment in forestry', 'Financing forestry', and 'Making the best use of the resources'. The three theme papers are published in full in this issue. Summaries of other papers appear in September, December and the forthcoming March issue.

The reports from Commonwealth Forestry Departments covering the highlights since the 11th Conference were presented on a regional basis by rapporteurs. These reports will be forming the background for some of the 'Around the World' items. The proceedings of the whole conference are being published by the Canadian Forest
Delegates attended the official opening of a new $14 M extension of the Research Centre performed by the Minister of State for Forestry, Gerald S. Merrithew. Instead of the traditional ‘ribbon cutting’ he donned a hard hat and chain sawed through a young Douglas fir pole. The Minister chaired the opening session of the conference and hosted a banquet on behalf of the Canadian government.

The Forest Research establishments were one of the four attractions offered for the day tour, half way through the conference. Coaches left at 7.15 am to visit silvicultural demonstration forests, forest industry operations — logging and sawmilling or forest nurseries. All parties converged on the community of Sooke where the evening’s entertainment included a salmon barbeque, loggers sports and dancing to a country and western band.

The serious side of the conference involved the presentation and discussion of up to eight subjects a day with a short lunch break, but possibly of equal importance were the opportunities for delegates to meet each other and establish lasting ties. On the topic of ties, there were some 40 Association ties in evidence; they proved their worth when two of us needed to meet at Heathrow. The Honourable Thomas Waterman, Minister of Forests for British Columbia hosted a banquet on behalf of the Provincial government. His Honour, R. G. Rogers, Lieutenant Governor of British Columbia invited delegates to a reception. Among others who kindly offered hospitality were T. M. Thompson, Reid Collins and Associates, WAJAX and MacMillan Bloedel.

Commonwealth Forestry Reception

The Association reciprocated some of the hospitality received with a reception at the Oak Bay Beach Hotel, a charming old world setting complete with log fire, oak beams and overtones of golf and sailing. Within ten minutes of the first guest being welcomed by our Vice President, Christopher Latham, some 80 people were in animated conversation and two of our local honorary secretaries from Tasmania and Zimbabwe were providing stimulating dance music from the piano. The Australians had set the evening off to an excellent start with their reception in the Empress Hotel, the UK contingent received some home hospitality en route for the Oak Bay Beach. Forest investment policies were still being discussed into the early hours. At 5 am a party set off for a successful salmon fishing trip.

Conference Recommendations

Previous conferences have produced numerous resolutions, some of which are still bearing fruit such as the Association itself and the tropical pine research work based upon Oxford, but whilst there may have been consensus of opinion within the Commonwealth forestry camp there were fears that the world outside might not have had its thinking influenced. After this 12th Conference the participants endorsed the following recommendations for presentation to the November, 1985 meeting of Commonwealth Agricultural Ministers in Rome:

- that vigourous steps be taken immediately to raise the level of public awareness and appreciation of the broad spectrum of forestry, to encourage rational debate on management issues;
- that forest policies be based on multiple-use principles with the appropriate balance of environmental and commercial objectives;
- that there is an urgent need for new initiatives to control the rapid rate of forest depletion and to improve the standard of regeneration after harvest:
that there is a need to promote integrated rural development plans in tropical and sub-tropical countries to relieve pressures on natural forests; that, in view of the crisis of forest and land degradation in many developing countries, governments should intensify current action programmes, and, in doing so, take as a guideline the doubling of international assistance called for by the FAO and World Resources Institute; that forestry agencies actively promote the role of forestry as an integral part of rural development, and in particular, to address the fuelwood crisis in developing countries; that existing training programmes be reviewed and that investments are made, to ensure an adequate number of professionals, technicians and forest workers are trained and that there are adequate career paths developed; that priorities for research should take account of practical relevance and prospects for applications to ensure the most effective use of available funds; that stumpage and wood pricing policies be reformed with the aim of increasing financial resources for forest renewal.

Autumn Meetings (Late 1985)

A meeting was held during the conference. The Association’s chairman was leading a party of foresters on tour in China and this Canadian meeting was taken by the Vice President, Christopher Latham. He welcomed the new members who had joined during the conference and expressed particular pleasure at seeing a meeting which included seven of the Association’s Local Honorary Secretaries. Following the report on the major events since the Trinidad conference, suggestions affecting membership and the Review were welcomed for consideration by the Executive Committee.

An open meeting in High Wycombe, Buckinghamshire followed the October meeting of the Executive. Our host was the veneer firm of Richard Graefe, sporting the house colours of James Latham, PLC. Members were introduced to the merits of crown and quarter cut veneers, inspected sliced logs of European species including Taxus, Fraxinus and Larix, North American Quercus and Pseudotsuga, Australian Endiandra and tropical Berlina, Khaya and Chlorophora. Decorative panels, tables, doors and furnishings are custom made for over a hundred household names. The clients choosing from a selection of ‘logs’ before the item is commissioned.

The 1986 Annual General Meeting

The Association has been invited by Lord Dulverton, CBE, TD to hold its Annual General Meeting at his estate at Batsford in Gloucestershire. Our host is a past president of the Timber Growers Organisation. The suggested time is 12.30 pm on Friday, 23 May.

The International Forest Science Consultancy

The three partners of the Consultancy, based at 21 Biggar Road, Silverburn, Penicuik, Midlothian, Scotland, announce that the Government of Zambia has asked them, in collaboration with Arup-Atkins International and PEIDA to undertake a comprehensive study of forestry and forest industries within the country. Recent assignments for the consultancy include a biomass assessment in Botswana — in
conjunction with Energy Resources Ltd. and Huntings Technical Services, wood fuel appreciation in Zimbabwe, a feasibility study for integrated forestry and agriculture for the government of Vanuatu, work in Liberia and Indonesia and for the United Nations Sudano-Sahelian office, continued work in Ethiopia and Ghana on the role that tree planting can play in stemming the advance of the desert.

Statistical Methods for Agroforestry Research

Janey Riley, a biometrician with the ODA Statistics Department at Rothamsted Experimental Station, Harpenden, Herts, AL5 2JQ, England, is working with species being intercropped with annuals. She is planning a programme of research into statistical methods for the design and analysis of intercropping trials involving trees in combination with perennials, with annuals or with animals. To enable the statistical methods to be tested, data is needed from agroforestry trials, however small or complex, and any information about experimental designs and analyses currently in use. In return for such information received, it would be possible to provide up-to-date information about appropriate statistical designs and analyses and a suitable analysis of the data forwarded.

The Commonwealth Forestry Institute/Oxford Forestry Institute

Specialist Forestry Course: Oxford 1985
**Specialist Forestry Course: Oxford 1985**

The 1985 Specialist Forestry Course programme ran from 1 July to 27 September offering 23 modules to 61 participants from 26 countries. The three major social interest groups covered were Planning and Management, Social Forestry and Forest Research Methods. A book prize was awarded to one participant from each group who had, in the opinion of the course staff, made the best use of the time in Oxford. The recipients were F. S. Tambula (Malawi — Social Forestry), T. M. Nolan (Solomon Islands — Planning and Management) and M. Hafeez (Pakistan — Forest Research Methods). Mr. Hafeez was also awarded the Schlich Medal which is provided by the Association.

The Departments of Agriculture, Botany and Forestry at Oxford University have been amalgamated into the Department of Plant Sciences. The Commonwealth Forestry Institute, whilst continuing to give priority to Commonwealth members, has been renamed the Oxford Forestry Institute to denote its closer integration and greater academic recognition by the University authorities. The Director of the Institute is Dr. J. Burley.

**Supplementary maps for September, 1985 Review**

The article on ‘Wood as a source of fuel in Upper Shaba (Zaire)’ by Professors F. Malaisse and K. Binzangi in the September, 1985 issue of the *Review* was originally submitted with two maps which travelled safely between Africa and England, but failed to negotiate the hazards of Oxford to its suburbs. An appropriate page No. 240 was left clear and is enclosed as a loose sheet with this issue.

**Post Conference Tour**

The three-day coach tour of the southern part of Vancouver Island attracted 31 foresters and wives from 15 countries.

The island’s vegetation is considered in four biogeoclimatic zones. Coastal Douglas Fir — the trees dominating the vegetation are *Pseudotsuga menziesii, Thuja plicata* with some *Pinus contorta, Arbutus menziesii* and *Quercus garryana*. Land in the rain shadow of the Olympic Mountains of Washington State and the Vancouver Island Range has a cool dry summer and mild wet winter. The Coastal Western Hemlock Zone has higher rainfall, lower temperatures at higher elevation but with hot dry summers giving considerable fire danger. The forest canopy and understory is dominated by *Tsuga heterophylla*, Douglas- fir is still a major species in drier conditions but is replaced in wetter conditions with *Abies amabilis*. Mature stands typically exceed heights of 60 m on well drained soils. Soils with restricted conditions for rooting support low-productivity stands of lodgepole pine (*Pinus contorta*) and the Western Red Cedar (*Thuja plicata*) often suffer from die back of the upper crown producing typical ‘spike-tops’. The Mountain Hemlock Zone over 1,000 m has short cool summers and long cool winters with the depth of snow typically over 3 m. The Alpine Tundra Zone at heights over 1,600 m has a cold, windy, snowy alpine climate.

The tour was limited to the first two zones passing through two Forest Districts. The annual harvest from Duncan Forest District is 3M m³ with reforestation of 3.570 ha using 3.4 M trees and from the Port Alberni District, the annual volume of 4.3 M m³ comes from the logging of 5,810 ha.

The party was privileged to have the company of a young and active 86 year old, Gerry Wellburn who had sailed to Canada in 1909. He ran his own sawmilling business, had
been bought out by MacMillan and continued with them as a manager. It was he who had started the collection of trains and logging equipment which has become the British Columbia Forest Museum at Duncan. 'Museum' is an understatement for a train trip through forest and across the edge of a lake beside the memories of the logging pioneers.

Cathedral Grove was donated by H. R. MacMillan Company in 1944 and gives the visitor an opportunity to see coniferous forest at its climax, at least a point in 'climax' where Douglas-fir is still dominant but with younger western hemlock waiting in the wings. The British Columbia Provincial Parks looks after 335 parks — an area of 4,250,471 ha, with an additional 31 Recreational Areas (262,775 ha) and a Wilderness Conservancy of 131,523 ha. (The word 'park' has taken on new dimensions.)

The destination for the first day was Port Alberni, 'Salmon Capital of the World'. The Chamber of Commerce and Harbour Commission made the party most welcome. Very dry summer conditions had prevented deliberate slash burning until the first rains of autumn. Controlled fires are the first stage in regeneration — improving access to the soil and reducing the risk of unsupervised disaster. Although the visibility was impaired with smoke haze, the visitors were treated to the sight of a self tipping barge decanting the odd thousand logs into the sea in conjunction with a well timed water bombing drop by one of the Mars aircraft of Forest Industries Flying Tankers. These flying boats can takes up 6,000 gallons of water in 20 seconds whilst in flight. Those foresters who noted the direction of the prevailing wind, moved inland promptly after the demonstration. The evening was enlivened with discussion on the impact of logging on salmon and the results of monitoring some aspects of the research at Carnation Creek.
The following morning, the party was quite prepared to be impressed with the Mars at rest on their moorings but swirling fog frustrated even the most adventurous photographer. The impression of the island is one of rock, mountain, water and coniferous forest, such old forest as was seen appeared to be overmature with the skyline dominated by the dead tops of Western Red Cedar. The land is still rebounding from the removal of the ice from the last glaciation. Such alluvial areas as exist in the south were deposited in shallow seas in recent geological time. Logging has interrupted the repeated cycle of natural regeneration, over maturity and fire and the forest manager is presented with some understocked areas but many where the high density of regeneration is an embarrassment, increasing the length of rotation, giving undesirable volumes of suppressed trees which in turn increase the hazard of fire and beetle damage. The small trees which are undesirable are not considered big enough to be exploited economically. On these overstocked areas, the three logging and management companies who guided the party across their areas, Crown Forest Industries Ltd., MacMillan Bloedel Ltd., B.C. Forest Products Ltd., each demonstrated their attempts to 'thin to waste' either mechanically or chemically.

Lunch, on the edge of Kennedy Lake, a refreshing swim, an opportunity to view a panorama of coastal pine forest, a drive through the Pacific Rim National Park and
eventually we reached our furthest western point. Miles of uninhabited beach with enough firewood washed up on the shore to fuel the charcoal wants of an African state. Tall pine grew vertically within a stone throw of the high tide mark. The one building, ‘The Wick’ provided a splendid seafood supper as we watched the sun sink into the Pacific.

The first stop the following morning was China Creek, a log storing yard of MacMillan Bloedel Ltd. where 1.237 M m$^3$ of timber was handled annually from the Franklin River. Cameron and Estevan Divisions. Trouble during storage had been suffered from Ambrosia beetles attacking the logs. The Company had set up 120 pheromone traps around the yard with low grade pulpwood stacked in the vicinity. The traps themselves had caught 425,000 Trypodendron lineatum and 19,000 Gnathotricus sulcatus whilst the removal and processing of the pulpwood shortly after the major beetle attack in early June further reduced subsequent beetle populations. Further information may be obtained from one of our new members, Shan Krannitz, Phero Tech Inc. 1140 Clark Drive, Vancouver, B.C.

British Columbia has 27,000 km of pollution free coastline and countless freshwater rivers and lakes. Those on the tour had an introduction into the fish and oyster farming industry. In 1984, Norway produced 20,000 T of farmed Atlantic salmon, Japan produced 4,600 T of farmed Pacific salmon and British Columbia produced 107 T from its rapidly expanding salmon farming industry. The eggs take 8 months in fresh water to produce a smolt which after a further 7 months in sea water can reach a ‘pan sized’ 300 gm; two more years and the fish can weigh 4 kg. Most of the Canadian farmed salmon are coho but the numbers of chinook are increasing and there are prospects for the use of sockeye, chum and pink. The weight of Rainbow Trout farmed in fresh water in Canada in 1984 was 80 T. It is thought that there would be no great difficulty in selling twice this amount. In addition to the oyster industry which is already well established, there are commercial possibilities for farming abalone, scallops, mussels and black cod. (Further details from the Ministry of the Environment, 780 Blanchard St., Victoria, B.C.)

Some 12,000 ha of Franklin River basin was logged between 1934 and 1957 using equipment powered in part by steam but with access dependent upon the construction of logging railways. Up until 1954, access was by boat, via the Alberni Canal and then by railroad ‘speeder’ to the current site of the lumber camp. The area’s annual production in the late ‘30’s was about 100 M board feet. The bunk houses were moved by rail as each new logging area developed and the site used in 1954, with extra accommodation for 360 men, made the complex one of the biggest logging camps in the world. Truck logging commenced in 1954 and had replaced the railways by 1957. The ‘town’ was phased out in 1984 but briefly opened again in September 1985 to offer us refreshment and an opportunity for a slash burn inspection. The management, initially Bloedel, Stewart and Welch Ltd., had introduced the first power saw, a German Stihl, in 1936 and in 1942 brought in the ‘hard hat’ as protective head gear.

The tour’s guide, Doug Adderley of the Ministry of Forests, arranged yet another delightful water-side site for lunch, the bank of the Nitinat River, collecting its water from the 1,491 m Mount Hooper. The river forms the boundary between our hosts of the morning, MacMillan Bloedel and those who would show us the delights of Lake Cowichan, British Columbia Forest Products. Two of the species which appear as successful colonisers after the removal of conifers from lower ground are an alder (Alnus rubra) and varieties of maple (Acer). Neither of these is welcome and it transpired that the demonstration of ‘Alder rehabilitation’ compared the comparative merits of killing it with Krenite, 24D and stem injection with ‘round up’. The forest immediately around the 35 km long lake is regrowth after logging and is already producing commercial timber and with improved access is giving the Canadian forester an opportunity to consider the
merits of thinning and silviculture. The foresters, in addition to their interests in ensuring that the forests provide a sustained yield of timber of the appropriate species and sizes, are already grappling with the demands of amenity, the deer population and the need to keep the streams and environment free from pollution.

The final stop of the tour was a raised roadside platform, provided to offer a view over the expanse of Cowichan Lake which, instead, demonstrated just how splendidly the local natural regeneration of Douglas-fir could rise to heights unforseen by the engineering department.

Anyone fortunate enough to visit Vancouver during Expo '86 is strongly encouraged to visit Vancouver Island, to visit the museum at Victoria, Buchart Gardens, the Forest Museum at Duncan and to liaise with Information Services of the B.C. Forest Service, 1450 Government Street, Victoria, B.C. to ascertain whether there are any vacancies on their next coach trip.

Christmas Spruce Problem

International forest authorities are attempting to ensure that the origin of seed used for establishment should be of known appropriate provenance. Within the EEC, Supplier’s Certificates FRP 2B should abide by Forest Reproductive Material Regulations (S.1.1977 No 891) –66/404/EEC amended 75/445/EEC and 71/161/EEC. Green labels will be used for Selected Reproductive Material and blue labels for Tested Reproductive Material.

The records of one of the Norway spruce (Picea abies. Karst) provenance assessments at the European Spatial Agency have suffered damage by fire. Assistance is sought in correlation of residual information. The survival numbers out of 1,000 plants in five trials are 402, 504, 604, 704 and 840. The average heights achieved were 8 cm, 11 cm, 14 cm, 17 cm and 20 cm — not in order of survival numbers. The five seed batches originated from France, Poland, Germany, Czechoslovakia and Romania. The reference numbers — in no particular order — are NORWY /SALZ, D 840/13, A0411/4379, 2PLITA and 84019/0663. The following information which survived the fire should be adequate for those with the time available to allocate accurately the details of each experiment.

Over 550 plants of Polish origin survived as did another country’s plants of A0411/4379 provenance which were the tallest. The Romanian trees of 2PLITA origin produced trees over 15 cm but less than 550 survived. The 704 trees which survived had an average height of 8 cm and were not of 84019 provenance. The German trees averaged 11 cm. The D.840/13 trees had the lowest survival, they were not French. the French trees were bigger than 10 cm. The best survival was with the Czech trees, their average height was not 14 cm.

An Association tie will be forwarded to the member who can provide the most erudite solution to the Spatial Agency problem, before the 8 August, 1986.
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When replying to this advertisement, please mention the Commonwealth Forestry Review.
The Editor
The Commonwealth Forestry Review
29 October 1985

Dear Sir

"An Integrated silvicultural Solution to Weedy climber problems in the Solomon Islands."

I read this article in the June 1985 edition of the Commonwealth Forestry Review (Vol. 64(2)) with considerable interest, particularly since I see Graham in Munda from time to time.

Following my association with the line enrichment planting programme in the Solomons from its inception until 1980, I have since consistently argued that line planting has its place in tropical forestry when properly applied. My confidence in the system is based on successes and mistakes: an alternative analysis of some of the early data produced by Miller and subsequent visits to the Solomons after 1981; and assessments of line planting in Fiji.

Prompted by the article, I reread my paper on "The Development of Line Planting in the Solomons". I wryly remember that it was written in some haste for the 1976-78 Forest Rangers Course in Kolombangara, and omitted to record one of the reasons why the main UK Aid funded project failed to follow Dawkin's criteria in all particulars. In 1974 to 1976 only 333 stems per hectare were planted at 10 m x 3 m because constraints on the nursery, at the time, precluded the production of seedlings for a more closely spaced planting programme.

From 1970 to 1974 line planting experiments I established used 10 m x 2 m spacing to increase the likelihood of natural selection of 100 final crop trees per hectare. This spacing was never introduced in the main planting programme. By 1979/80 the programme was reduced and it would have been possible to plant at 10 m x 2 m and introduce 5 m x 3 m spacing for species like Gmelina arborea on heavily logged areas near roads with soil disturbance, thus offsetting many of the impracticabilities subsequently recorded.

I only saw a small proportion of Miller's field data. At the end of 1979 I did some trial assessments with him on 1968 plantings of Campnosperma brevipesultata on Gizo, to investigate the numbers of well formed trees in lines planted with 2 metres between trees. A one-in-five rate of natural selection of final crop trees from 500 stems per hectare (sph) at 10 m x 2 m would give a target of 100 sph. While from 333 stems per hectare only 65 sph could be expected as was found in many sections of the lines assessed by Miller.

Subsequently, I have recommended in a number of locations that if line enrichment planting in forest soon after logging you aim to produce 100 final crop stems per hectare, you must plant the appropriate species (e.g. Swietenia or Campnosperma) at 10 m x 1.8 m (or even 10 m x 1.5 m) in logged high forest that retains much of the original understorey or has vigorous early regrowth of weed free species like Tremat and Macaranga. But where there is heavy soil damage and invasion by Merremia and Operculina, planting at 5 m x 3 m with a different range of species is more appropriate.
I would like an opportunity to revisit a management trial on Kolombangara in which alternating lines of *Swietenia macrophylla* and *Leucaena leucocephala* were planted in 1979. This type of plantation, using legumes including *Acacia mangium* has, I believe, considerable scope in areas where fuel wood and poles are in high demand, but where industry could use a timber species of higher value later on.

Yours faithfully
K. D. Marten
(Groome & Associates)

Forestry Investment Management Ltd
25 Archery Fields
Odiham
Hants, RG25 1AE

The Editor
The Commonwealth Forestry Review

28 October 1985

Dear Sir

100,000 Jobs: Forestry P.R.

The following brief has been submitted to the editorial board of the Parliamentary Year Book for 1985 which is issued free to all members of both Houses of Parliament. I seek to present the case for forestry in simple terms, drawing attention to its potential contribution to the national economy, for employment and for the improvement in the quality of life in rural Britain. I hope that you will consider that some of the Association’s members would find useful suggestions for the promotion of forestry in their several countries.

1. **The U.K. Timber Industry**

   The U.K. relies heavily on imported timber and timber products, at a cost of £3,800 million in 1983 and nearly £4,500 in 1984. This represents 90% in value of wood products consumed in the U.K., including over 60% in pulp, paper and board, about 25% in round timber and sawn wood, and the rest mostly in panel products.

   Timber is the U.K.’s second largest import, second only to food. World shortages and higher prices are predicted. The question inevitably arises, therefore, of how Britain will pay for these products on this scale, when North Sea oil begins to run out in the next 15 or 20 years. The answer comes in further development of the timber industry, aimed at not less than 50% self-sufficiency after the next two decades.

   The key to economic success lies in the integration by geographical regions of timber growing, and full scale, fully modernised wood-processing industries. The by-products of one industry will move on as the raw material of the next, thus ensuring full utilisation of the forest products. There will be a short haul between the timber in the forest to the saw mills and the pulp and paper mills. Only thus will the industry become competitive by world standards, and only thus will it survive and prosper.
2. **Land Availability**

Post-war policy envisaged the establishment of two million hectares of managed forest in the U.K. by the turn of the century, in order to replace losses in the two world wars. This now seems well capable of achievement, after allowing fully for the needs of conservation, landscape planning, wildlife protection and recreation there is more than enough suitable land to meet this demand.

Less than 10% of land in Britain is under forest, compared with an average of 21% over the whole of the E.E.C.

3. **Contribution to the National Economy**

The contribution to the national economy is best measured by the output of the processing industries.

In Wales, for example, assuming a coniferous forest of 200,000 hectares (currently 168,000) in sustained yield, with well-planned supporting industries, there is the prospect in due course of a contribution at present prices, of more than £200 million annually to the Welsh people. There is an almost identical situation in Galloway and Dumfries in South West Scotland. The tree planting programme should be maintained in each region until the target of 200,000 hectares of coniferous forest has been achieved. The processing industries will then follow, progressively, as and when there is an assured and continuous supply of raw materials, sufficient for the purpose. Given slower growth rates in other parts of Britain a larger forest area will be needed to achieve the same result in those regions.

As the Welsh coniferous forest production should be about 10% of the national forest, it may be concluded that the U.K. softwood industry is capable of contributing more than £2,000 million each year to the national economy. Adding the production of the broadleaved woodlands, the nation as a whole can become not less than 50% self-sufficient. This is not a theoretical exercise. Looking forward it is a practical possibility.

4. **Employment and Social Considerations**

Current employment in forestry, the wood-processing industry, and haulage and delivery has been given as 25,300 as at 31st March 1985. There is expected an immediate upsurge as substantial new industries come on stream in 1985/86, and others are expanding production. At least double the number of jobs should come on offer by the turn of the century, capable under these plans of rising to more than 100,000 in the following decade.

Roadworks will be necessary inside the forests for low-cost extraction facilities, these being a highly important feature of the economy. More especially, however, in the rural infrastructure, there will be needed improved roads and bridges to carry 30 ton loads into the mills and factories. More than 20 million tons of timber will eventually have to be moved every year, in large and heavy vehicles.

There will be a revival of rural communities, with their required social services of housing, shops, schools, churches, hospitals and recreational facilities. In New Zealand, it should be noted, there is one fully integrated timber industry in one locality supporting, it is said, a population of 15,000. The biggest manufacturing industry in the country it now has a high export potential, and has already achieved significant export figures. The movement of exotic timber, essentially radiata pine, represents some 25% of New Zealand rail freight. Surely here we have the necessary inspiration.
5. **Conclusion**

Timber in the U.K. is truly a growth industry, its sale proceeds accruing perhaps only 12% to the growers and 88% to the hauliers and processors. Properly planned it can contribute dramatically to the national economy, and to the quality of life in rural Britain.

To establish the foundations of such an important industry, continued government encouragement and support is essential for the timber grower. The industries will follow once the plantations are in production.

I would like to endorse your own efforts encouraging foresters to cultivate the soil on which their trees rely and also influencing the political climate which in turn can affect the welfare of the foresters along with the rest of the community.

Yours faithfully

K. N. Rankin

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José Truda Palazzo, Jr.
Rua 24 de outubro, 100/2301
Porto Alegre – RS 90000
Brasil

November 4, 1985

Dear Sir

As a Council member of the Brazilian Foundation for the Conservation of Nature and also member of the Commonwealth Forestry Association, I take the liberty of asking you to publish the following comments on the article entitled “The Brazilian Amazon Region: Forestry Industry Opportunities and Aspirations” (Commonw. For. Rev. 64(2), 1985) by Professors Correa de Lima and Mercado.

Some conservationists in Brasil are totally against the “rational” use of the Amazonian forest, and they have very good reasons for that. That’s not my personal view, and I think that rational management of the forest should be allowed. However, it’s saddening and surprising to learn that some people still regard the Jari Project (a complete disaster from the ecological point of view), as a “successful experiment” as they “utilised” the existing natural forest and afterwards sterilised the land with “selected exotic species”. The illusion of a huge reforestation effort is also a lie from the ecological point of view when you speak of the whole country, where no ecologically affordable reforestation projects with native species are being implemented.

Nevertheless it’s good to see that Professors Correa de Lima and Mercado acknowledge the need for research and the suitability of sustained management projects like that installed by FAO/IBDF near Santarem.

As a matter of fact, when we read the last part of the article, we can actually see that old and — we can even say — ‘pathological’ approaches to the tropical forest environment are still growing in the brains of our “forestry scientists” when they regard the Amazonian forest as “natural resource which hitherto has contributed little to the economy”. It may be true that the technocracy, fortunately, has still not sold the whole forest to export, but the tropical forest as it stands, is immensely important to the lives of millions of people who depend upon it — indians, fishermen, and all other natives whose rights are often easily forgotten when our authorities are blinded by the myth of the “unexplored resources” of Amazonia.
Finally, the concept of “taming” the Amazon region seems typical of a mentality that induces Mankind to fight against Nature and rape it until death. I strongly believe that we should rather learn how to live with the natural forests and preserve the genetic richness they contain, using its resources wisely through a rational management that avoids dated and short term solutions as advocated in the article.

Thank you very much for your attention and for considering these comments for publication.

Yours sincerely,
José Truda Palazzo Jr.

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NEWS OF MEMBERS

R. M. Bennett, who received an MBE after his 14 years in Vanuatu, has completed an ODA scholarship in Business Administration at Cranfield, UK and is working as Forestry Adviser to the Comorian Government on a World Bank project based at Moroni (BP 345), RFI Comores, (Indian Ocean.)

Roger T. Bradley, FICFor, FIWSc, has succeeded the late John Kennedy as Commissioner for Private Forestry and Development in the UK Forestry Commission. After graduating with an Honours Degree in Natural Science in 1959 from Oxford, he served the Forestry Commission at Alice Holt in mensuration, later as Working Plans Officer, in West Scotland as district manager, three years as Assistant Conservator in South Wales, as Conservator for North Wales and then as senior officer for Wales. In 1983 he became head of Harvesting and Marketing at the Edinburgh Headquarters.

John Coldwells graduated from Bangor in 1949 after 7 years in the Royal Air Force. He spent 6 years in Ghana and 18 years in Malawi, staying on after independence as Director of Forestry and Game. He moved to South Africa in 1973 and retired last year from the Department of Forestry in Natal. He is looking forward to making contact with any contemporaries: his address is: 7 Chilton Place, Chase Valley Downs, 3201 Pietermaritzburg.

David L. Foot, Conservator for South Scotland since 1983, has been appointed as the Head of Harvesting and Marketing at the Commission’s headquarters in Edinburgh.

John Howell has moved to a larger farm, Dolmelynlyn, Ganllwyd, Dolgellau, Gwynedd in Wales. His recent consultancy visits have included the countries of Indonesia, Belize, Barbados, Ecuador and the Dominican Republic.

Geoffrey Gray has retired from Forestal International Ltd. after 17 years and has moved to 239 Bayview Road (PO Box 349). Lions Bay, British Columbia VON 2E0. He is working as an independent consultant in the international field.

Jennifer Johnson, who has experience in Lesotho and Alaska and was formerly undertaking research funded by ODA at Oxford, has been appointed a Research Associate at Cambridge University where she is carrying out an appreciation of private forestry taxation.

Peter B. Lavery of the Victorian Department of Conservation, Forests and Lands in Australia, is benefitting from a Commonwealth Scholarship and Fellowship to spend a year working on the management and silviculture of Pinus radiata for the New Zealand government, based upon the University of Canterbury.

Dr. R. M. Lawton is working as Forestry Adviser in the Sultanate of Oman and may be contacted through the Ministry of Agriculture and Fisheries, PO Box 467 Muscat, Oman.

Stephen O’Neil, whilst registering visitors to a holiday centre at St. Jean de Luz, encountered the Association’s printer. He was able to hear that the June issue had been deliberately delayed so that publication would not pre-empt the congress in Mexico.

Dr. S. N. Rai has been promoted to Conservator of Forests and his present posting is a head of the Sandal Research Centre, 18th Cross, Malleswaram, Bangalore 560003. This centre is one of the units of the Forest Research Institute at Dehra Dun.

Margot Spence of the Faculty of Forestry in the University of British Columbia has
been awarded one of the 20 scholarships of the Soil Conservation Society of America. Her work in developing countries will encourage natural resource and environmental appreciation.

Roy Strang reports on the meeting of Edinburgh forestry graduates at ‘Holyrood House’ on Vancouver Island during the Commonwealth Forestry Conference. Cabled greetings were received from Dr. John Burnett, Principal and Vice-Chancellor of the University with the message . . . may you all walk as tall as your big trees . . . . The select band included R. G. Miller ’31 from New Zealand, W. Finlayson ’47 from Oxford, R. M. Strang ’50, D. L. Handley ’52, F. Hegyi ’61 and Mrs. Hegyi, J. T. Arnott ’63 and Mrs. H. Arnott, I. Bodley-Scott ’65 and D. Price all at present in British Columbia. Kwasi Kese ’57 from Ghana, G. Symes ’61 from Jamaica and M. Chihambakwe ’80 from Zimbabwe. Good wishes were sent by P. Barker, A. Orr-Ewing and P. H. Pearse from B.C., Connor Boyd from Washington, J. C. Lees from New Brunswick and Murray Little in Saskatchewan, Mike Crown, David Foot, Alec Harper and G. M. and Mrs. O’Neill were thought to have encountered navigational problems with either the sasquatch or the ogopogo.

Dr. Wink Sutton has been appointed Tasman Forestry’s strategic development and technology consultant, a full time executive post.

John Wholey, who served as the Association’s LHS when in Hong Kong, is now living at Mill House, Lower Street, Salhouse, Norfolk. NR13 6RW.

David Wigston is the new Professor and Head of the Department of Forestry at the University of Technology, Lae, Papua New Guinea. He was previously the Head of the Woodlands Research Group at Plymouth Polytechnic, UK.

OBITUARIES

Leo Frank Edgerley

Leo Frank Edgerley, former Conservator of Forests in Mauritius (1949–1962) passed away on 12th December, 1983, at the age of 82. Before 1949, he was Assistant Forest Officer, then Tutor at the Forest Training School in Rangoon. During the war he served as a Civil Affairs Officer and rose to the rank of Lt. Colonel and was awarded a Military O.B.E. Returning to Burma after the war in 1945–46 he went back to the Forest Training School as Director; he remained there until Burma received her Independence in 1947. He also served for a very short period as Assistant Conservator of Forests in Mauritius. In 1950, he re-organised the department and collaborated with Mr. W. Allen in writing a White Paper entitled ‘Crown Forest Land (Land Utilisation) and Forestry’. From September 1962 to October 1971, he also served as member and on several occasions as Acting Chairman. Public Service Commission, Mauritius.

A. W. Owadally

Hugh McIntyre

Hugh McIntyre, one of the Association’s oldest Life Members passed away in Pietermaritzburg, Natal on 2/5/85. Hugh became a member of the former Empire Forestry Association in 1924 and a Life Member in 1930.
His early Forestry training was served on the Darnaway Estates Morayshire and on the outbreak of World War I, Hugh enlisted in the Seaforth Highlanders (51st Highland Division) and later in the Royal Tank Regiment.

In 1921 he joined the Kenya Forest Department and was responsible for surveying and establishing several new Forest Stations and the training of new staff. He served in all the main Forest Stations in the West Conservancy until retiring at Londiani in 1948.

Hugh is survived by his wife Isobel, his son Duncan, who is an engineer in W. Africa and daughter Jean who lives in Kenya.

W. MacDonald

John Youl

John Youl, O.B.E., 1 February 1902 — 8 July 1985, began his long career in forestry and the timber industry in 1917 when he enrolled at the Victorian School of Forestry, Creswick, becoming the youngest student ever to successfully complete the Diploma course. He served in several forest districts in Victoria until 1934, when he became manager of the State Timber Seasoning Works, and later Marketing Officer for the State Forests Department. He was a key participant in organising the salvage of timber after the catastrophic fires of 1939 and the supply of timber to Australian and allied defence forces. He was also responsible for the annual production and distribution of half a million tons of firewood for domestic and industrial use. From 1944 until 1968 he was manager of the Victorian Sawmillers Association, and he served on many industry and government committees and organisations. Since 1968 he had been engaged in consulting work, mostly in connection with integration of sawmilling with woodchip and pulp production. He had been a member of our Association since 1957. In 1971 John was honoured for his services to the timber industry. He is remembered with deep affection by many friends and associates for his integrity, gentlemanly example and friendly counsel.

A. Eddy

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DREW, B., Teacher Training College, Bama, via Ministry of Education, Maidugari, P.M.B. 1046, North Bornu, Nigeria
JEDDERE-FISHER, H. K., 22 Longcroft Close, Basingstoke, Hants RG21 1XG
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MCINTYRE, H., 18 Mills Circle, Pietermaritzburg
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YOUL, J. W., 1/41 Rockley Road, S. Yarra, Victoria 3141, Australia


23/5/86 ENGLAND, Batsford. Commonwealth Forestry Association AGM and outing. Ref: M. T. Rogers, CFA, Oxford Forestry Institute, South Parks Road, Oxford.

3/6/86-8/6/86 CHINA, Shanghai. China International Agriculture and Farming Exhibition. Ref: Jane Staley, CHINA EXPO, 553-579 Harrow Road, London W10, UK.

30/6/86-2/7/86 USA, University of West Virginia. Symposium on Microcomputer Software for Forestry Application. Ref: D. O. Yandle, PO Box 6125, Morgantown, WV 26505-6125

1/7/86-6/7/86 GERMANY (FR), Munich. ‘Int. Trade Fair for Forestry’. Ref: The Secretary, Inst. Water Resources, University of Alaska, Fairbanks, AK 99701, USA.


11/10/86–11/10/86 CANADA. Vancouver. ‘40th Annual Meeting of Forest History Society’.
Ref: G. Wynn, Dept. of Geography, UBC. 1984 West Mall, Vancouver BC. V6T 1W5.

20/ 8/87–30/ 8/87 KOREA. Seoul. ‘XVI Pacific Science Congress.’

Ref: R. L. Newman, AFDI, PO Box 515, Launceston, Tasmania 7250.

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BELIZE

The report to the 12th Commonwealth Conference offers the following details. The total land area is 2,296,200 ha of which 2,132,300 ha is forest. Closed forest is 1,581,200 ha, woodland and pine forest 98,700 ha and mangrove and swamp 240,800 ha, plantations 2,721 ha. The area scheduled as permanent forest area has been increased since 1980 by 34,600 ha to 672,300 ha. Of the 16 forest reserve areas, 22% of the land is considered as needing forests for the conservation of soil and water.

During the last four years the production from the 47 sawmills has dropped from 44,081 m³ to 38,719 m³ the mahogany and ‘cedar’ now being 9,200 m³, pine has increased by 8,135 m³ to 10,298 m³ and category listed as ‘hardwoods’ reduced to 19,221 m³. It has been calculated that the ‘hardwood’ forests could sustain an annual yield of 1.4 M m³. There are six major mills which account for 75% of the conversion.

The total population is 162,000 with about 900 being employed in private forestry and under 200 by the government. Cyprus has awarded two scholarships for technical training and Mexico, a scholarship for a degree course at Chapingo.

Some of the earliest records of logging date from the 1720’s when *Hamaetoxyylon campechium* was in demand for the dye industry. Subsequently the demand was for mahogany (*Swietenia macrophylla*), initially exported in the round, but now as veneer and lumber. Shortage of funds has forced a reduction in the modest reforestation process. The forests have the potential to offer an attractive return on capital invested in utilisation of the range of hardwoods available and in addition, benefit the local communities.

MALAWI

The Republic of Malawi, once known as Nyasaland, has a land area of slightly under 9.5 M ha. Forests and savanna woodland, typically *Brachystegia spp*, cover 1.7 M ha, the designated Forest Estate is 731,000 ha with a further 406,800 ha under negotiation. The area of State plantations is 88,200 ha, mainly *Pinus patula* at altitude and *P. kesiya* on lower ground with 14,400 ha of fuelwood using species of eucalypt. The fuelwood project has received help from the World Bank. The average annual consumption of fuelwood is 1.4 m³ per person; 90% of the population of 6.64 M use wood for heating and cooking. Industry uses 30% of the wood burnt, mainly for tobacco curing but also in brick making, in the preparation of lime and tea. Private plantations cover 9,250 ha.

The Forest Policy aims at self sufficiency in timber requirements, it acknowledges the important role played by trees protecting the environment, with 731,200 ha of protection forests, also the contribution which trees provide as a background for tourism. Tree protection and establishment are being fostered by government publicity but hill land is still being degraded by 3.5% per annum and fires are a major problem, destroying 2,292 ha of plantation in 1984. Canadian help, through IDRC, has given encouraging results for dry zone planting with *Eucalyptus camaldulensis*, *E. tereticornis*, *Cassia siamea*, *Melia azedarach*, *Gmelina arborea*, *Albizia lebbeck*, *Acacia albida*, *Aziderachta indica*, and *Leucaena leucocephala*.

MAURITIUS

Situated in the Indian Ocean, the area of Mauritius is 185,000 ha with forests over 56,110 ha with 11,600 ha of plantation. The species used for plantations include *Pinus elliottii*,
P. iaeda, Eucalyptus tereticornis, E. hybrid, Araucaria cunninghamii and Casuarina equisetifolia. The State owns 21,657 ha of forest land of which 5,000 ha are rocky, unplantable or where protective tree cover must be retained and a further 4,585 ha are Nature Reserves. Privately owned reserved areas are 3,800 ha of Mountain Reserve and 2,740 ha of River Reserve. The remaining private forest area including scrub and grazing lands is about 28,000 ha. There is considerable interest in venison, a deer (Cervus timorensis) having been introduced from Java.

The annual cut of timber is recorded at 32,000 m³ with additional 22,146 m³ of firewood being sold (1983). The population is approximately 1 M with 50% being under 15 years old. The forest staff, including those on the island of Rodrigues, is 2,285. The forests produce about 30% of the timber requirements, they are an important source of firewood and fodder, a species Setaria sphacelata being deliberately planted between timber species.

It is important to keep tree cover on water catchments to regulate stream flow, to prevent erosion of fertile soil and to prevent flooding.

The main sawmills are Grewals (Mauritius) Ltd. with a staff of 80. There are two other medium mills, 47 small mills and a match factory.

USA: ALASKA

The following 'thumbnail sketch' is contributed by Jenny Johnson.

The earliest inhabitants of Alaska called it ‘Alyeska’ — the great land. With a present total population of only 400,000, a coastline of 34,000 miles and a total area of 152 M ha, it is hardly surprising that many now call it 'the last frontier’. A quarter of an hour from Anchorage International airport one is within sighting distance of some of the highest and most dramatic mountains in North America. It is largely because of these mountains, and because there are only three to four months of the Arctic year when an hospitable front is presented to exploration, that the enormous wealth of natural resources has been protected from the usual inroads made by prospectors, commerce and tourists.

Although the country ranges between latitudes 50° and 73° North of the equator it is anything but the barren arctic waste it is often made out to be. Anchorage is roughly on the same latitude as Oslo, Stockholm and Leningrad. The bulk of the country lies north of 60°N and winter temperatures inland may drop to −60°F although summer temperatures can soar to over 90°F.

There are two forest ecosystems in Alaska. The coastal forests of south-eastern Alaska are an extension of the rain forests of Oregon, Washington and British Columbia, but with a different species distribution. Western hemlock (Tsuga heterophylla), Sitka spruce (Picea sitchensis) and Western red cedar (Thuja plicata) are the dominant trees: Alaska’s interior forests differ from those on the coast and are usually referred to by the Russian term taiga. They cover about 44 M ha or 29% of the land area and are part of the vast band of coniferous forest circling the northern hemisphere. White spruce (Picea glauca). Paper birch (Betula papyrifera) and aspen (Populus tremuloides) are the main forest trees found on relatively warm, well-drained sites. Black spruce (Picea mariana) and tamarack (Larix laricina) occur on the poorer sites, with or without permafrost.

More than 9.4 M ha of the taiga has been inventoried as commercial forest land, that is, land capable of producing at least 1.4 m³ per ha per year of usable wood. (Wood production throughout Europe averages about 3 m³ per ha per year). The scheduled harvest target for Alaska is 4.5 billion board feet per decade and much of this will be met
from the taiga which is estimated to have a total net sawtimber volume somewhere in the region of 31 billion board feet. This will mean sacrificing much of the old-growth forest — something which is causing increasing public concern because of the potential impact on wildlife.

The abundance of Alaska's wildlife is quite staggering and one does not have to live long in Alaska in order to appreciate this. This abundance presents a strong pull for the tourist industry which is growing rapidly; more than 300,000 visitors enjoy Denali National Park, home of Mount McKinley, each summer. The forest industry remains a threat as current methods of harvesting create a permanent loss of habitat for many species of wildlife. However there is room to balance the economic and environmental scales. In many parts of Alaska the constraints on harvesting, such as remoteness and poor quality wood, are so great that it is unlikely ever to take place on a large scale. Wildlife would be protected in these places by default. But there are equally vulnerable places which are much easier to exploit. Alaska clearly has a need to order her priorities. The Alaska pipeline has proved that development of the remoter regions is not impossible and roads and planes have opened up even the most isolated communities. The recent land grab process has affected all Alaskans. Conservationists, petroleum companies and local residents vie with each other for claims on land. What is not clear is how, with so much genuine wild country, Alaska will take the opportunity to avoid the environmental blunders of the other states and develop policies which will protect those very qualities which make it attractive.
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DEFORESTATION ISSUES IN DEVELOPING COUNTRIES
THE CASE FOR AN ACCELERATED INVESTMENT PROGRAMME

By J. SPEARS*

Preface

The Economic and Social Costs of Past Failure to Address Deforestation Issues

The current status of the developing countries' forest resources and the negative impact of deforestation have been already well documented elsewhere.\(^1\)\(^2\)\(^3\). Whilst many of the various scientific studies which have examined the underlying causes and effects of deforestation have been well done, the forestry profession itself has so far done a poor job in translating these studies into an effective Action Programme.

For the last two decades most national governments and aid agencies have been so preoccupied with the enormity of trying to feed the Third World's exploding population, that more than 95\% of all aid agency agricultural investment has been channeled into projects that have, as their basic objective, short-term food production. Investments in agriculture, education, in human nutrition, health and the like, have invariably taken precedence over the need for protection of the basic land and natural resources on which human survival will ultimately depend. For example, forestry conservation investment by the development banks over the last decade amounted to less than 1\% of their total investment.

Past failures by both national government and the international community adequately to invest in forest conservation, in watershed rehabilitation, in anti-desertification, soil, erosion control and other environmental protection measures, have had an extremely high economic and social cost.

Some of the decline in agricultural productivity, the increase in food shortages, human suffering and environmental damage which developing countries are facing today could have been avoided by greater political commitment in the past to investment in natural resource conservation.

To quote from a recent World Environmental Commission Report:\(^4\)

"Long range programmes that would have helped to tackle the underlying problems have received comparatively little support. The anti-desertification programme adopted by the UN in 1977, for example, was largely ignored by donor and recipient governments alike. That programme, it is interesting to note, was estimated to cost US $4.5 billions per annum to the year 2000 for the entire globe. A breakdown of this figure reveals that the estimated cost for Ethiopia was US $50 million per year to the year 2000. Neither the political will nor the money could be found to implement this programme, however. Yet, eight years later, faced with a human drama beyond precedent, the world community has had to find an estimated US $400 million for crisis-response measures to date for Ethiopia alone, and this figure will undoubtedly exceed US $500 million before the next harvest. It will go well beyond that if the harvest fails again. The arithmetic of prevention is almost always persuasive: somehow we have to invent a politics of prevention that can match the politics of crises."

As will be shown in this paper, spontaneous tree planting and conservation initiatives are beginning to emerge. Given appropriate government policies and institutional

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support, there is much that can be done through well designed forestry investment programmes to help accelerate those grass root movements and to contain the negative effects of deforestation in the worst affected countries. We already have technical solutions to many of the problems caused by deforestation and it has been clearly demonstrated that forestry conservation and development projects can earn sufficiently high rates of return to be self sustaining.

The external aid support required to begin to make a more effective impact on these issues (about US $800 million a year for the next five years, i.e. about double the current level of external aid flows) — would still amount to only 2% of total OECD aid flows to Third World countries.

Deforestation Issues in Developing Countries: The Case for an Accelerated Investment Programme

Deforestation has halved the area of forest and savannah woodlands in the developing countries since the turn of the century. Despite all the efforts of national governments and the international aid community the rate of deforestation is increasing — 11 million hectares a year are being lost. Lack of political awareness of the negative impact of deforestation on human welfare and on the environment and inadequate past investment in forest conservation are two of the major constraints to bringing deforestation under control. Annex 1, attached, summarises the current status of forestry in developing countries listing those in which the impact of deforestation is most severe.

The first part of this paper briefly summarises the main issues, i.e. the impact of deforestation on:

- Agricultural productivity
- Desertification
- Watersheds and stream flow
- Fuelwood availability
- Industrial wood supplies
- Loss of biological diversity in tropical rainforest ecosystems

The second and main part of the paper is intended to demonstrate that enough is already known of technologically proven, socially acceptable and economically viable approaches to forest conservation, to justify an immediate escalation in current levels of investment. It describes examples of past successful investment projects with a high pay off which could be replicable on a much larger scale and identifies some of the key policy issues that will need to be addressed in the course of project design and implementation.

One of the main points being made is that contrary to earlier conventional wisdom, investment in both forest conservation and development can pay its way.

The point is also made that the climate for investment in forestry in the Third World is improving, mainly because the millions of people in these countries whose lives are adversely affected by deforestation are doing something about it themselves. Increasing scarcity of fuelwood, which implies more time spent by the women and children of rural households in collecting wood and fodder, rising prices and a growing awareness of the fact that forests and trees are fast disappearing, have triggered a spontaneous response.

Grass-root movements involving small farmers, local communities, schools, NGO’s and in some instances the private sector in afforestation and forestry protection programmes are gaining ground. Examples are cited throughout the paper.
The challenge for both national governments and the international aid community is, how most effectively to support these spontaneous initiatives and to help accelerate the process of developing country forest protection and reforestation.

In the last section of this paper an Accelerated Investment Programme is suggested that would approximately double the level of external aid investment in forestry in the period 1987–91. More importantly, it would broaden the scope of investment in the forestry sector to allow for a more integrated approach to interrelated deforestation, desertification, watershed rehabilitation, soil erosion, agroforestry, energy and forest conservation related issues. Thirty percent of the recommended investment would be for agricultural support services that could provide small farmers or shifting cultivators living in or adjacent to threatened forest areas with a viable alternative to further forest encroachment.

Details of the programme by region are summarised in Table 5 and in Annex 2. The total cost of that programme over a 5 year period would be about US $8 billion of which US $6 billion would be needed for 58 priority countries defined by FAO as being those worst affected by deforestation.

This accelerated investment programme represents almost a doubling of current levels of forest conservation investment. It is assumed that about half of this total would be sought from overseas aid sources with the balance being provided by a combination of small farmer, private sector and national government investments. Even this increased level of external aid investment would still amount to only 2% of annual aid to Third World countries.

The proposals made are based mainly on the recommendations of Action Programme priorities defined by FAO’s Committee of Forest Development in the Tropics and the findings of a joint World Resources Institute/World Bank/UNDP Task Force study which has examined past successful project experiences. Based on a review of national government development plans and consultation with developing country forestry leaders it has prepared a country by country accelerated Investment Programme for 58 priority countries for the coming five years.

The keys to achieving the proposed Programme would be, firstly, top level political commitment to the programme by national governments. Secondly, strengthening of forestry sectoral planning and implementation capability at both national government level and in the various international aid agencies, and third, the availability of an additional US $2 billion in external aid funding over a five year period.

Out of the 58 countries listed in the Accelerated Investment Programme, 16 are Commonwealth Countries the incremental investment requirements of which would amount to US $1.8 billion, this being about 30% of the total programme.

**Economic Returns to Forest Investment**

The long period of time needed for trees to grow to marketable size and the waiting period between the time of initial investment in forest planting and generation of revenue from timber harvesting have, over the years, generated a conventional wisdom that forestry projects yield low rates of return. That unfortunate over-simplification and characterisation of forestry has been one of the principal reasons for the relatively low levels of past investment in the forestry sector.

In preparing its 1978 Forestry Sector Policy paper for example, the World Bank made special reference to problems of economic analysis in forestry and acknowledged these might well act as a constraint to achievement of its forestry lending targets.

By hindsight, the difficulties perceived at that time have proven to be more imaginary
than real. Investment by the development banks* in forestry now exceeds US $1.5 billion spread over some 50 different countries. As can be noted from the case studies cited in this paper, this investment has covered a wide range of forestry activities from watershed protection, to fuelwood, social/agroforestry, anti-desertification projects, protection of threatened tropical forest ecosystems, forestry research, education, training and extension.

In practice, economic rates of return for many of the agroforestry and environmental protection projects financed by the development banks have earned considerably higher rates of return than those of industrial forestry projects. (Table 1).

### Table 1

Comparative rates of return for some of the forestry projects financed by the World Bank**

<table>
<thead>
<tr>
<th>Category of Project</th>
<th>No. of Projects Financed</th>
<th>Range of Economic Rates of Return (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Plantation Forestry</td>
<td>15</td>
<td>10–15</td>
</tr>
<tr>
<td>Agroforestry/Fuelwood</td>
<td>27</td>
<td>15–30</td>
</tr>
<tr>
<td>Watershed Rehabilitation</td>
<td>8</td>
<td>15–21</td>
</tr>
</tbody>
</table>


Whilst there have been some notable project failures in this sector, on balance the track record of past financed projects has been satisfactory. An important lesson that has emerged from past projects is that, given appropriate pricing, land tenure policies and institutional support (which are essential and significant components of all forestry investment projects) a doubling or more of current rates of afforestation over a 5 year period has been achieved in some countries.

### The Catalytic Role of External Aid

Whilst considerable emphasis is given in this paper to the role of external aid, it should be clearly acknowledged at the outset that in terms of the total resource flows needed in the longer term effectively to tackle deforestation issues, the external aid agencies can provide at best only a marginal contribution.

Secondly, it is important to clarify that intensive levels of investment that are characteristic of first phase projects because of the heavy emphasis in institution building can be significantly reduced once projects reach the take-off stage.
The main role of external aid is to act in a catalytic way and to help in devising new approaches for dealing with these problems. It can help to create the infrastructural and particularly human and institutional framework for forest conservation and protection programmes. Also to tackle some of the basic policy issues and constraints to increased investment.

The most successful aid financed forestry development projects in the past have been those where a combination of national government effort and political commitment assisted by external aid or private sector investment have succeeded in creating an investment climate that triggered an accelerated and spontaneous response from local farmers, communities and the private sector, for larger scale self-sustaining programmes. The project experiences described in this paper in Gujarat, Haiti, and the Philippines are good examples of that approach.

**Deforestation: The Issues**

**Impact of Deforestation on Agricultural Productivity**

The main cause of deforestation is expanding population pressure and conversion of forest land to agriculture exacerbated by inequitable land tenure policies. Fuelwood harvesting and commercial logging are also important contributory causes. The effects of deforestation on agriculture have been a shortening of fallow periods, increased crop residue and animal dung burning leading to a decline in agricultural production. In small farm situations, crop residue burning removes most of the organic mulch from the farming system and this has a negative impact on crop yields. In semi arid zones where tree fodder accounts for at least 20% of the livestock feed requirement of transhumant populations, deforestation and desertification have resulted in shortages of animal feed and enforced migration away from desertified areas.

In most developing countries, investment in reforestation and in particular, in management of natural forest, is lagging way behind the level needed to maintain an adequate stock of farm trees and forest cover and to supply human needs for fruit, fodder, poles, fuelwood, timber and other forest products. Total elimination of trees and protective shelterbelts from farm systems can reduce food production by 20% in the short term, particularly in arid zone environments. In the longer term it can hasten soil erosion and lead to loss of substantial areas of agricultural land.

To illustrate the same point in another way, keeping their forests, trees and woodlands in place could have significantly helped to reduced Third World dependence on imported food grains and famine relief programmes.

**The Effect of Deforestation on Watersheds**

In developing countries, deforestation in upland watersheds followed by excessive grazing and cultivation of steep slopes has led to soil erosion, increased run-off, sedimentation of downstream dams and disruption of stream flow.

The lives of some 500 million people in 30 countries are adversely affected. Increased sedimentation shortens the life of dams and reservoirs. For example, the life of the Tarbela dam in Pakistan which was originally planned for 50 years has now been reduced to less than 20 years as a result of excessive sedimentation due to upstream deforestation, overgrazing and cultivation of steep slopes. India, Nepal, Indonesia, Ethiopia, Madagascar, Haiti and Colombia — are all experiencing similar problems. Soil erosion on deforested slopes in Ethiopia affects half of the country’s land area. Some 2,000 T of
top soil per km$^2$ are lost each year. Flood damage in India below the deforested areas of the Himalayan range has required emergency investment averaging US $210 million a year over the last decade. On a global basis some 150 M ha of watersheds are in need of rehabilitation.

**Desertification**

Particularly in the countries of the Sahel–Sudanian Zone, deforestation has been a contributory factor in the desertification process and lowered crop yields, mainly as consequence of accelerated wind erosion of top soil and reduced moisture availability in the top soil. The main underlying cause is excessive human and livestock population pressure. The sustainable carrying capacity of the savannah rangelands of the Sahelian region is about 15 people per km$^2$ compared with an actual density of 20 per km$^2$. Fuelwood, available from the natural forests of the region is sufficient to meet the needs of 20 million people compared with an actual population of over 30 million. A most intractable issue is the inherent conflict between graziers on the one hand who depend to a high degree on the savannah woodlands as a source of livestock feed and the interest of fuelwood gathers on the other whose primary interest is maximising income from sale of fuelwood or charcoal.

**Fuelwood**

Twenty-seven developing countries are facing an acute fuelwood crisis and in a further 30, fuelwood harvesting greatly exceeds the sustainable cut from the remaining forest and woodland resources. About 1 billion people are living in situations of fuelwood scarcity*. At current rates of deforestation and population increase, this will more than double by year 2000.

The fuelwood crisis acts as a constraint to economic development in three ways. Firstly, it requires that an inordinate amount of time be spent daily by the women and children of the household in gathering fuelwood. This has a negative impact on the quality of life and particularly health. Secondly, the rising cost of fuelwood in urban areas means that poor people have to spend a significant proportion of their household income in purchasing fuels, (about 25–30% in many urban townships). Third, as already noted above, crop residue and animal dung burning when fuelwood is no longer available has a negative effect on food production.

**Inadequacy of Industrial Forestry Protection and Management Policies**

Exploitation of industrial forests without adequate safeguards for conservation and protection is a contributory cause of environmental deterioration in several countries (e.g. Ivory Coast, Brazil, Indonesia, Philippines). Logging roads provide access for agricultural encroachment. The acid latosols which underlie much of the tropical rain forest are unsuitable for sustained annual food cropping. After a few years, cultivated areas are abandoned and revert to coarse grass and bush of low economic value.

In 12 developing countries* properly managed tropical hardwood forests have the potential to make a significant and sustainable contribution to foreign exchange earnings

* Cameroons, Congo P.R., Gabon, Ivory Coast, Liberia, Zaire, Indonesia, Madagascar, Papua New Guinea, Brazil, Peru.
DEFORESTATION IN DEVELOPING COUNTRIES

(over US $100 M a year). However, current levels of reforestation and management are quite inadequate to ensure that future wood supplies can be maintained and most of those countries will experience a sharp decline in export trade before 2000 unless swift remedial action is taken to protect what is left of the natural forests and to invest in accelerated reforestation. Countries like Nigeria for example, which until quite recently were major exporters of forest products, are now becoming massive net importers despite ecological conditions which are favourable for establishment of fast growing industrial plantations. Nigeria’s forest product imports are running at over $250 M a year. They will double by 1995.

Preservation of Tropical Forest Ecosystems and Gene Pool Resources

In 36 developing countries there are unique forest ecosystems that are threatened by agricultural encroachment, commercial logging or fuelwood harvesting. These ecosystems contain many plant and animal species that could become extinct before the turn of the century unless remedial action is swiftly taken. Many of the pharmaceutical drugs in world use derive from tropical forests, including some which can be used for treatment of cancers. These ecosystems include some of the most biologically diverse gene pool reserves remaining on the planet and their extinction would have implications of global concern.

Examples of successful forest conservation and development projects that have potential for replicability on a larger scale

Past development bank lending experiences suggest that enough is already known of technically proven and economically viable solutions to deforestation to justify an accelerated response. Annex 3 summarises past and current development Bank investment and grant aid support to forestry which is currently running at about US $400 M a year of which investment by the development banks accounts for about 50% and grant aid assistance, mainly for technical assistance support and institution building, the balance.

Many of these externally assisted projects have been sustained for 10 years or more and the periodic monitoring studies carried out by a combination of government, development bank and FAO staff provide valuable lessons of experience which are important in relation to designing future action.

In the following section, examples of successful projects that have potential for replicability on a larger scale are briefly summarised and some of the key policy issues that will need to be addressed in designing an Accelerated Investment Programme are identified.

In compiling this overview three important observations need to be made at the outset:

(a) Problems of watershed rehabilitation and desertification cannot be solved by investment in the forestry sector alone. These are broad land use issues that require an integrated approach to agriculture, forestry and rural development.

(b) Resolution of the fuelwood crisis will require simultaneous investment in energy efficiency, conservation and substitute fuel programmes. Because of currently low farm gate prices for fuelwood, in the medium term (5–10 years), fuelwood supply-side projects will often need to be closely integrated with wider agroforestry and industrial forestry programmes.
Additional forestry investment cannot be effective unless it includes strong emphasis on institution building, extension and research and includes provision in project design for addressing policy issues such as the role of women in tree planting, pricing policies for both fuelwood and industrial wood and land tenure constraints.

Examples of Successful Projects

Agro-forestry

The role of farm trees and forests in helping to sustain agricultural productivity via e.g. shelterbelt effects and by direct food production (fruit, fodder, nuts, honey, etc.) can be readily quantified. More than 70% of the fuelwood and minor forest products used in developing countries are derived from on farm trees, shrubs or woodlands that are not under government control.

Here are three examples of successful agroforestry projects:

India — Gujarat

The Gujarat experience which has been well documented elsewhere is perhaps the most well publicised example of farmers spontaneously responding to cash market incentives for poles, fuelwood and other forest products. Once these wood products really became scarce and prices began to rise, farmers' response to a government programme that provided subsidised seedling and extension support was little short of amazing. The rate of planting increased four-fold between 1975 and 1979 from 12 M trees per year to 48 M per year, doubled again to 100 M by 1981, and yet again to 195 M by 1983. For the state's population of around 15 M this represents an impressive accomplishment of the planting of over 10 trees per person a year. Within 3 years at least 10% of Gujarat's farming population have been involved in government assisted farm forestry and by 1983, the equivalent of over 150,000 ha had been planted.

Survival rates have been good. Similar experiences have been recorded in several other Indian states.

Of a total 5 year project cost of US $76 M, of which US $37 M was met by a World Bank loan, investment in staffing support costs, research training and fellowships accounted for 25%. The projects economic rate of return was 15%. Some individual farmers' financial returns were in the range of 20–30%.

The key policy issue that needs to be addressed as the programme continues is how to ensure that the benefits of such programmes reach the poorest of the poor. Efforts being made in West Bengal for example, to involve the landless in cash crop tree farming are of particular interest.

Philippines — PICOP

This is another well documented example of a successful agroforestry programme.

The programme gained significant momentum in 1972 when PICOP entered into an arrangement with the Development Bank of the Philippines (DBP) to develop a loan programme for smallholder tree farming. Loans were offered to smallholders to finance...
Table 2
Philippines Smallholder Tree Farming Project

Cash flow and financial rate of return for a 10 ha *Albizia falcatoria* tree farmer (US$ 1980)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Year</th>
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<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Accumulative planted area (ha)</td>
<td>—</td>
<td>4</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>10</td>
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<tr>
<td>Annual area harvested (ha)</td>
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<td><strong>Net Cash Inflow</strong></td>
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</tr>
<tr>
<td>Loan</td>
<td>640</td>
<td>640</td>
<td>320</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>828</td>
<td>864</td>
<td>958</td>
<td>958</td>
<td>1034</td>
<td>1111</td>
<td>1111</td>
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<tr>
<td>Net Revenue</td>
<td>—</td>
<td>—</td>
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<td>—</td>
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<td>—</td>
<td>—</td>
<td>828</td>
<td>155</td>
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<td>249</td>
<td>352</td>
<td>402</td>
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<tr>
<td><strong>Net Cash Outflow</strong></td>
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<tr>
<td>Investment*</td>
<td>665</td>
<td>675</td>
<td>343</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>709</td>
<td>709</td>
<td>709</td>
<td>709</td>
<td>709</td>
<td>709</td>
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<tr>
<td>Debt Service</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>828</td>
<td>155</td>
<td>249</td>
<td>249</td>
<td>352</td>
<td>402</td>
</tr>
<tr>
<td><strong>Net Cash Flow</strong></td>
<td>(25)</td>
<td>(35)</td>
<td>(23)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>828</td>
<td>155</td>
<td>249</td>
<td>249</td>
<td>352</td>
<td>402</td>
</tr>
</tbody>
</table>

Financial Rate of Return computed over 25 years = 22%

* Compounded at 12%.
75% of the costs of plantation development and maintenance. Farmers with titled property could receive loans at a 12% rate of interest; farmers with unsecured property could receive loans at a 14% rate of interest. PICOP continued to guarantee a minimum purchase price for smallholder production, but allowed farmers to sell wood to other outlets if they could get a better price. The scheme proved quite popular with farmers. By 1981, the programme supported 3,800 participants and covered 22,000 ha. Around 30% of these farmers had taken advantage of the credit programme. 

There were several weak areas in the project design, (particularly lack of adequate support for harvesting of the wood)14-15, nevertheless, the overall lesson is that given adequate market incentive and security of land tenure, then government (or private sector) assistance through improved availability of seedlings, extension advice and access to credit can help significantly to accelerate spontaneous tree planting initiatives.

In the PICOP project the key factor which triggered farmers response was, as in the case of Gujarat, the prospect of making handsome profits from tree growing. Table 2 illustrates the farm budget for a Philippines tree farmer. Financial rates of return for participating farmers in that project have ranged typically between 20 and 30%.

### Costa Rica

Trees which provide shade, fruit, fodder, building poles, and which may enhance the fertility of soils can also produce fuelwood. Multiple-objective programmes have achieved a significant rate of success in involving smallholders in growing trees. In Central America, the Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE), has explored innovative ways of introducing different types of trees into smallholder production systems. CATIE persuaded 900 farmers in the Piedades Norte areas of Costa Rica to plant around 50,000 trees by encouraging them to try different types of planting strategies, such as live fences, shade trees and windbreaks. A variety of multi-purpose species were made available at local nurseries, and farmers were quick to incorporate trees into their farming systems mainly in this case for their own domestic consumption but in some areas also for resale.

Other development agencies, such as the InterAmerican Development Bank, are now actively exploring how to translate these experiences into larger scale programmes. The Asian Development Bank is already supporting a similar forestry programme in Bangladesh and plans to extend its support to social forestry programmes elsewhere in the Asian region.

The challenge for development banks and other donors is how most effectively to encourage these spontaneous tree planting initiatives? The highest priority should be given mass media programmes aimed at encouraging forest conservation and tree planting, to providing research and extension support and to devising new institutional approaches for involving farmers, particularly women, and the private sector in accelerated afforestation programmes (e.g. via credit programmes). Also by encouraging government forest agencies to lease areas of degraded forest or agricultural wasteland to farmers or local communities (as for example, is being tried in various Indian states). Key policy issues and priority areas for technical assistance support include sociological research aimed at testing farmer attitudes to tree planting, development of low cost technologies such as direct seeding and involvement of schools. NGO’s and local communities in tree seedling production programmes instead of Governments trying to do all the seedling production themselves.
Agroforestry programmes carried out by farmers and local communities are characterised by significantly lower investment costs than the alternative of government financed plantations (US $250–300 per ha versus US $800–1,250 per ha for government financed forestry plantations)\textsuperscript{16}, mainly because of the much lower infrastructure and overhead supervision costs for on-farm planting. Rates of return for farm forestry investment programmes typically range from 15–30% compared with 10–15% for government planting.

**Watershed Rehabilitation**

**Ethiopia**

In Ethiopia, past FAO World Food Programme experience working with Peasant Associations has considerable potential for replication on a larger scale\textsuperscript{17}.

Terracing and planting of steep slopes with Eucalypts began in the 1960's. Since the severe drought of 1968–70, the World Food Programme (WFP) has been assisting Ethiopia in watershed rehabilitation through "Food for Work" projects. This has developed into one of the world's largest soil conservation projects consisting of geographically scattered demonstration pilot projects where training and project works (such as check dams, terraces, reforestation, etc.) were undertaken. Based on this experience, the Soil and Water Conservation Department (SWCD) of the Ministry of Agriculture launched a second phase in 1982. This has doubled the size of the programme, with 2.2 M ha in 35 catchments being treated. With contributions from the EEC and Australia to the "Food for Work" programme, annual expenditures have reached US $66 M. Other donors are also supporting small irrigation schemes.

In 1980, FAO began a large training project with UNDP financing to strengthen the capacity of SWCD to implement the programme. This was expanded in 1983 to meet the increased demand for trained personnel. The target is to train 270 technicians, 1,067 district agents, and 18,250 Peasant Association leaders by 1986 at a cost of US $2.6 M.

Although impressive progress has been made, the current programme covers less than 5% of the area in urgent need of improvement.

The above scheme provides a classic illustration of how grant aid, technical assistance and pilot scale projects can together provide a solid basis for expanded investment with prospect of high environmental payoff. A scheme has been recently put forward for expanding the Ethiopian WFP programme to cover a total of 100 watersheds for which US $150M will be required. The World Bank, African Bank, together with other donors, are currently examining the possibility of providing part of the loan/funding needed to support that programme.

Similar projects already supported by development banks in Kenya\textsuperscript{19}, India\textsuperscript{19}, Nepal\textsuperscript{10} and elsewhere have demonstrated high economic rates of return. A key point made earlier in this paper is that watershed rehabilitation project design needs to be broadly based and to provide farmers living in those watersheds, with an alternative to forest and rangeland destruction. As Table 3 clearly illustrates, reforestation investments alone cannot adequately achieve this objective. Other agricultural and institution building inputs often comprise more than 50% of the total investment package in a well balanced watershed programme.
### Table 3
Principal Cost Components for five Bank-financed Watershed Rehabilitation Projects
(In US $ M 1982)

<table>
<thead>
<tr>
<th>Project Component</th>
<th>Philippines Watershed Management and Erosion Control</th>
<th>India Himalayan Watershed</th>
<th>Nepal Himalayan Rural Development</th>
<th>Thailand Northern Agriculture Development</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost % of Project Cost</td>
<td>Cost % of Project Cost</td>
<td>Cost % of Project Cost</td>
<td>Cost % of Project Cost</td>
</tr>
<tr>
<td>Agriculture Development including horticulture and livestock</td>
<td>4.0 35</td>
<td>18.0 30</td>
<td>2.7 30</td>
<td>16.0 44</td>
</tr>
<tr>
<td>Irrigation and Flood Control</td>
<td></td>
<td>3.0 5</td>
<td>1.2 13</td>
<td></td>
</tr>
<tr>
<td>Soil Conservation and Reforestation</td>
<td>1.0 9</td>
<td>24.0 40</td>
<td>1.2 13</td>
<td>9.0 25</td>
</tr>
<tr>
<td>Infrastructure (access roads, tracks)</td>
<td>1.5 14</td>
<td>3.0 5</td>
<td>1.1 12</td>
<td>2.0 6</td>
</tr>
<tr>
<td>Non-agriculture enterprise development</td>
<td>1.5 14</td>
<td></td>
<td>0.2 1</td>
<td></td>
</tr>
<tr>
<td>Project management extension, training and research</td>
<td>1.5 14</td>
<td>14.0 20</td>
<td>1.5 16</td>
<td>8.0 22</td>
</tr>
<tr>
<td>Social Services</td>
<td>1.5 14</td>
<td></td>
<td>1.3 15</td>
<td>1.0 3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>11.0 100</strong></td>
<td><strong>62.0 100</strong></td>
<td><strong>9.2 100</strong></td>
<td><strong>36.0 100</strong></td>
</tr>
</tbody>
</table>

Source: World Bank Data

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** Arresting Desertification in Drought Prone Areas **

** Sudan **

Anti desertification programmes, particularly in the Sahelian Zone also require an integrated approach, including involvement of local communities in natural forest and savannah woodland resource management, resettlement of people in the Sudanian
Guinean Zone, continued and expanded research into more drought resistant, high yielding millet and sorghum varieties. Also into fast growing tree species suitable for drought prone environments.

There needs to be simultaneous emphasis on improved livestock husbandry and upgrading of fodder supplies. In relation to energy policy more effective control and management of fuelwood forests, continued emphasis on reduction of energy demand and use of incentives to encourage greater investment in forestry management and fuelwood planting.

The design of a project carried out in the Southern Darfur region of Sudan in the 1970’s illustrates the range of components needed to make effective ecological improvements in arid zone areas. It illustrates the same point made above when discussing watershed rehabilitation; namely that, forestry investments on their own can only make a partial (although critical) contribution to addressing broader issues of watershed rehabilitation and desertification.

The Southern Darfur project provided measures for improving the way of life of some 25,000 families in the area by allowing a more efficient utilisation of land resources. A settlement programme was initiated with the dual purpose of opening up presently blocked stockroutes and increasing crop production.

The opening up of stockroutes was vital for the annual migration of the transhumant families and their livestock. The project included settlement and crop production programmes with major emphasis on extension services, programme specific adaptive research, and pilot crop marketing schemes. Range management encouraged local populations to set aside dry weather grazing reserves and livestock development components including veterinary services, livestock related adaptive research, and non-formal education of livestock producers. The project also included improved maintenance and further development of water facilities; project monitoring and evaluation. The forestry component included technical assistance for gum arabic production. Incremental benefits from gum arabic production accounted for about 25% of net economic benefits from the settlement and crop components.

The forestry component of the Darfur project was not systematically monitored but results from a similar scheme, in neighbouring Kordofan, have been well documented. One of the components of that programme involved providing rural farmers with Acacia senegal seeds and seedlings. Reforestation was integrated into a comprehensive rural development programme which was intended to restore traditional rotational farming in a pilot area of 500,000 ha. Other objectives of the activity included the provision of improved water supplies and health facilities.

Despite early setbacks to the project, nearly 1,000 farmers participated during the first year. Although farmers were primarily motivated by assured income from the sale of the gum arabic, they also expressed interest in planting Acacia to improve the soil and to increase their fuelwood supply.

Currently USAID, and a number of other donors are examining the scope for replicability of these experiences on a larger scale. Key issues that would be examined within the context of project design include land tenure, and gum arabic pricing policies.

**Fuelwood**

In designing fuelwood projects, past experience suggests the need for inclusion in project design of a broad range of strategies for addressing the fuelwood crisis including increased use of substitute fuel, and more emphasis on improved end-use efficiency (particularly by improved charcoal production and use of improved stoves). In semi-arid
zones because of very slow growth rate of fuelwood trees, supply-side initiatives can usually only make a partial contribution to meeting fuelwood requirement. (In the Sahel zone, probably less than 40%)\textsuperscript{23}.

Supply-side solutions in semi-arid regions should aim at involvement of local populations in management and protection of existing natural slow growing savannah forest resources. In regions where more favourable ecological conditions prevail, accelerated on-farm afforestation programmes with fast growing multi-purpose species can make a significant impact on fuelwood supplies.

In areas where ecological conditions favour fast tree growth and where land availability is not a constraint, industrial scale energy plantations, producing fuelwood or charcoal as a substitute for use of coal, gas or oil will also have an increasing role to play as and when oil prices again begin to escalate.

The following examples of successful development projects illustrate three alternative approaches to tackling the fuelwood crisis. The first via conservation measures, the second by involving farmers in cash crop fuelwood farming and the third instance, through a large scale private sector investment in charcoal production.

**Ghana**

A successful programme for recovering wastewood and improving efficiency in charcoal burning was initiated by Government of Ghana with FAO support in the 1970's\textsuperscript{24}.

In many areas of Ghana the high forest has been extensively cut-over to remove the best quality and most valuable hardwood, leaving behind “degraded” forest which was not very productive from an economic point of view.

In 1971, Ghana embarked upon a reforestation programme to convert degraded natural forest with fast growing exotic tree species, mainly for the production of timber and pulpwood. The traditional conversion technique involved cutting and burning the remaining forest cover and replanting the entire site. The programme fell behind schedule because of very high costs and finally was stopped when funds were no longer available. The main reason for very high costs were:

(a) the energy potential of the remaining forest cover was not being recovered to reduce clearing costs:

(b) newly planted trees could not compete with the heavy invasion of secondary vegetation which springs up when high forest is cleared, burned and left unattended:

(c) local people moved in without authorisation to plant food crops (chiefly maize) in the areas of cut and burned over forests, adversely affecting the growth and survival of the planted seedlings.

In 1974, the government requested assistance in making and marketing charcoal from trees being cleared from the tropical high forest. A UNDP financed project started in 1976 in the 58,000 ha Subri River Forest Reserve. It soon succeeded in demonstrating that clearing costs could be drastically reduced by converting waste wood to charcoal (with new kilns developed by the project that use only 6 m\textsuperscript{3} per ton of charcoal compared with 12 m\textsuperscript{3} for traditional earth kilns). It also demonstrated that the operation could be carried out at a profit.

The intensified conversion method yielded immediate financial benefits which exceeded the regeneration costs by several hundred dollars per hectare. Additional socio-economic benefits resulted from increased employment.
Haiti

In Haiti farmers have been quick to undertake cash crop tree growing to supply urban fuel demands. A programme of farm forestry sponsored by the PanAmerican Foundation and USAID followed earlier community based efforts which were abandoned because of the lack of any strong tradition of communal cooperation. There are however, strong traditions of private ownership, and many families have access to land — which is for the most part unsuitable for agriculture. While other social forestry programmes in Haiti have emphasised the environmental benefits of tree planting, this scheme emphasised financial profitability. Non-governmental organisations have assumed most of the responsibility for starting tree nurseries, and seedlings are supplied to farmers at cost. Between 1981 and the end of the 1983 rainy season, around 4 M trees had been planted by around 6,000 participating households.

Some industrial scale fuelwood projects are also capable of showing attractive financial returns as illustrated by the following example from Brazil.

Brazil

Charcoal’s reducing properties are useful in extraction where it is held to be as good, if not better than coke. Charcoal-iron industries exist in Brazil, Argentina, Malaysia, Australia and India. The Brazilian steel-making firm “Acesita” uses about 500,000 T of charcoal a year for steel smelting, half of which is supplied from *Eucalyptus* plantations grown specifically for the purpose. Starting in the early 1970’s, by 1980 the company had planted more than 200,000 ha of fast growing *Eucalyptus* plantations. It has extensively tested alternative charcoal manufacturing methods, brought in small scale producers as subcontractors, responsible for plantation management as well as charcoal production, and it is moving ahead with research trials aimed at increasing the productivity of its plantations via intensive biomass techniques based on vegetative propagation and close espacement techniques. Investment costs have been in the order of US $300 per ha and financial rates of return about 15%. Success of the project has been due to:

- A fiscal incentive programme that stimulated private sector support.
- Use of fast growing *Eucalyptus* species with high growth rates and short rotations.
- The favourable ecological and climatic conditions for forestry prevailing in the State of Minas Gerais where the plantations are located.

The Role of Agroforestry in Helping to Resolve the Fuelwood Crisis

Until supplies of freely available natural forest or savannah woodland are almost exhausted, fuelwood farmgate prices in many developing countries will remain too low to trigger large scale spontaneous private investment in free standing energy plantations. Nevertheless, much fuelwood can, and is being produced as an integral component of multi purpose agroforestry (or industrial) forestry programmes. Twenty-two forestry projects with fuelwood components have been financed by the World Bank during the last five years. None of these projects would have been economically viable had fuelwood production alone been the main objective. However, combined with sales of other forest products (poles, pulpwood, timber, etc.), all of these projects demonstrated acceptable economic rates of return. 66% of total physical output was fuelwood.

Using agroforestry as one way to tackling the fuelwood crisis also has positive implications for increasing agricultural productivity.
Industrial Forestry

Several countries have clearly demonstrated that domestic self sufficiency in industrial wood supplies can be achieved within two decades by a combination of intensified management of natural forest plus planting of fast growing industrial species. Countries like Thailand, Philippines, Malaysia, Nigeria, Ghana, Ivory Coast, Congo P.R., Sierra Leone, Liberia, Argentina, Ecuador and Nicaragua in which current rates of overcutting or scarcity of natural forest will exhaust timber supplies within the foreseeable future urgently need to accelerate current levels of investment in fast growing industrial plantations.

Key policy issues to be addressed within the context of industrial forestry project design include how to encourage domestic processing of timber instead of log exports; to improve marketing of tropical hardwood products, to intensify utilisation of secondary species and to ensure more equitable stumpage and export taxation policies. The scope for involving the private sector in fast growing industrial reforestation programmes has not been adequately tested and government policies that offer long term security of tenure to the private sector are vital. Strengthening of weak forest administrations is a key area for continued development and support.

The two examples cited below (Malaysia and Zambia) illustrate alternative approaches to increasing industrial wood supplies in the former by making more intensive use of existing natural forest species (through utilisation, research, aggressive marketing and quality control), and in Zambia by replacing the slow growing natural forests with fast growing plantation species.

Malaysia

The importance of the home market in the utilisation of the lesser known species in a situation of dwindling forest resources and a well developed timber industry is well illustrated by the experience in Peninsular Malaysia. Here there are 39 plywood/veneer mills and 644 sawmills processing logs, both for export and for an expanding domestic market. Although there are local shortages of logs, supplies are generally adequate. However, it is projected that shortages will be experienced toward the end of this century. Thus, Peninsular Malaysia is now beginning to bypass the utilisation

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Log Intake</th>
<th>Other Light Hardwoods</th>
<th>Other Light Hardwoods as Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>1708</td>
<td>84</td>
<td>4.9</td>
</tr>
<tr>
<td>1978</td>
<td>1522</td>
<td>135</td>
<td>8.9</td>
</tr>
<tr>
<td>1979</td>
<td>1912</td>
<td>217</td>
<td>11.3</td>
</tr>
<tr>
<td>1980</td>
<td>1892</td>
<td>259</td>
<td>13.7</td>
</tr>
<tr>
<td>1981</td>
<td>1738</td>
<td>222</td>
<td>12.8</td>
</tr>
</tbody>
</table>

Source: FAO 1985
problems of the lesser known species. Choice species are exported while lesser known species are mainly sold in the home market. This development is well demonstrated by analysis of the log intake of sawmills and plywood mills in Terengganu, one of the east-coast states. (Table 4).

Timber species here have been classified into three main hardwood groups: heavy, medium and light hardwood. Species in each group are enumerated. However, with forecasts of declining forest resources, an increasing volume of other light hardwoods is now being used, consisting of a mixed bag of lesser known species. As shown in Table 4, the utilisation of this group more than doubled during the five year period between 1977 and 1981.

By 1981 lesser known species accounted for about 12% of the total log intake of sawmills in Peninsular Malaysia. The lesser known species intake of plywood/veneer mills was even higher, (27%). It has to be stressed that fuller utilisation of the lesser known species is possible in the case of Peninsular Malaysia only because of the presence of a well developed log processing industry coupled with a relatively sizeable local market. Similar experience in Nigeria has made it possible to increase the number of species marketed per hectare from 5 in 1955 to over 40 in 1980.

From a development banking viewpoint, the key issue is that with comparatively small investment in protection of the natural forest and what Wadsworth has defined as "Zero Management", the productivity and profitability of natural forest management can in many countries be expected significantly to improve as additional domestic markets for lower grade species begin to develop.

Notwithstanding that observation, the fact remains that in the majority of developing countries, supplies of remaining natural forests are simply insufficient to meet future wood needs and inevitably there will have to be simultaneous investment in fast growing plantations. Zambia is a good example of a small African country that has successfully ensured its future industrial wood needs by investment in plantations.

Zambia

In the 1950s, it became evident that to ensure supplies of industrial timber for mining operations for the long-term future, it would be necessary to establish industrial plantations. Some earlier planting had not been successful because of the combined effects of insufficiently deep soils, a seven-month dry season and intense competition from aggressive local grass and wood vegetation. The Forest Department therefore began an intensive research programme to determine appropriate species and silvicultural techniques. By the mid-1960s, using its own resources, the Government was successfully planting about 800 ha area of eucalyptus (primarily Eucalyptus grandis) and began to think in terms of a large-scale, long-range afforestation programme. World Bank financing was sought for assistance in the first phase of this programme.

Over a period of 15 years, some 35,000 ha of Pine and Eucalyptus plantations were established at an investment cost of about US $2,000 per ha. The project was completed in 1983. Its economic rate of return was about 12%. In a third-phase project, logging, road construction, maintenance of existing plantations, training issues and improvements in the efficiency of the sawmilling industry are being addressed.

The main reasons for the success of this Zambia programme were:

A well conceived and managed research programme which cost less than US $5 M clearly demonstrated the potential for growing Pines and Eucalyptus and paved the way for an investment of about US $50 M in fast growing industrial plantations.
High standards of plantation maintenance and fire protection were maintained. There was a sustained political and financial commitment to the forestry programme by Government of Zambia through the 15 year development period.

Similar examples can be cited for several other countries, notably Chile, Kenya, Swaziland, Portugal and Malawi. The largest fast growing industrial plantation programme in the world located in Brazil is referred to in more detail on a subsequent page.

The InterAmerican Development Bank has been actively supporting such projects in Chile and Argentina and the Asian Bank is supporting a large plantation project in Malaysia.

Perhaps the most important aspect of industrial plantation forestry is its potential to intensify productivity of land. Most natural tropical forest management systems both in past and current day use are typically producing something between 2 m$^3$ and 4 m$^3$ per ha per annum on a sustained yield basis and over fairly long rotation (60–80 years). Even with additional investment and enrichment planting this can rarely be raised above 10 m$^3$ per ha per annum. By contrast fast growing industrial plantation programmes based on Gmelina, Albizia, Eucalyptus, Pinus, Cypress and other species, are capable of yields between 25 and 50 m$^3$ per ha per annum. Compensatory plantations of fast growing species clearly have an important role to play in taking the pressure of natural forests.

In theory all of the world’s industrial wood needs in year 2000 could be met from 140 M ha of well-managed fast growing plantations, i.e. only 5% of the world’s remaining natural forest area$^{29}$. Clearly this is not a practical solution for all situations but it does illustrate the important role which plantations can and will play in meeting the world’s future wood needs.

**Protection of Threatened Tropical Forest Ecosystems**

A compelling case has been by IUCN$^{30}$, IIED$^{31}$, FAO$^{32}$ and various environmental groups for more concerted action to protect unique plant and animal associations that are threatened with extinction and to maintain the biological diversity of this ecosystem for the benefit of future generations. The strategy for doing this ranges from strengthening of government reservation policies through more expenditures on scientific research. The crux of the issue is the need to relieve pressure for agricultural encroachment and commercial logging in areas adjacent to threatened forest ecosystems.

There have been some successful experiences, e.g. in Kenya where the planting of intensive fast growing plantation trees which act as a buffer zone around nature reserves combined with vigorous Forest Department action to protect forest nature reserve boundaries has made it possible to protect unique tropical rainforests in the Kakamega region for many years despite very high population pressure in adjacent areas.

The following example taken from Indonesia illustrates how a combination of political commitment and effective support from both national government and external aid investment have succeeded in protecting a unique forest ecosystem area.

**Indonesia: Dumoga–Bone National Park**

The Dumoga–Bone National Park (more than 90% in primary forest), located on the island of Sulawesi (Celebes), is renowned for its flora and fauna. The Park contains large populations of most of Sulawesi’s protected endemic mammals, and many of the island’s 80 endemic bird species occur in the Park.

The development of the area is very closely related to a World Bank funded Dumoga
Valley Irrigation Scheme. Concern about deforestation led to agreement between the government of Indonesia and the World Bank to develop and protect the watershed by establishing the Dumoga–Bone National Park.

The area had no conservation history before 1977. Population densities were low, and most of the land was covered by undisturbed primary forest. Demand for agricultural lands by a rapidly growing population, and the explosive increase of forest exploitation by the timber industry in the last few decades, stimulated interest in intensive irrigation development of adjoining lands and in conserving areas of undisturbed forests.

Based on work conducted between 1977–1979 by the Indonesian Directorate of Nature Conservation, World Wildlife Fund and the World Bank, three protected areas were established (Dumoga Wildlife Reserve, Bone Wildlife Reserve, and Bulawa Nature Reserve). In 1982 the three sites were combined to form the Dumoga-Bone National Park. The Park now contains several buildings including an office, education centre, field research station, staff and guest house: facilities for recreation and tourism, and it is associated with a newly developed Regional Nature Conservation Training School.

Watershed protection provides a strong economic justification for the Park’s protected status. The Dumoga Irrigation project aims for a threefold increase of the valley’s rice production through irrigation of more than 13,000 ha of prime agricultural land. To ensure the capacity of the upstream area to deliver a regular and abundant supply of water for irrigation, plans for the Park’s preservation were incorporated into the irrigation loan. By preventing forest clearance, the Park will also decrease the threat of flood to a nearby city, Gorontala, and reduce erosion that would otherwise lead to silting of the harbour.

Investment in the Park protection component of the overall irrigation/forest conservation programme amounted to approximately US $1 M (less than 2% of the total project cost). Similar examples of incorporating conservation components into development projects elsewhere have been described in a draft World Bank Wildlands paper.

The Role of Forestry Research

Much of the forestry research in developing countries is fragmented and lacking in focus on priority research topics that have the potential to make an early impact on productivity and rural incomes. A World Bank/FAO research paper presented to the XVII IUFRO Congress attempted to identify broad priority areas for future aid agency support. A particular concern in the short-term is the need for intensified sociological research to test farmer and local community attitudes to tree planting. Strengthening of tree breeding improvement programmes for multipurpose species suitable for on-farm and agricultural wasteland reforestation, scope for increased biomass production in fuelwood forests and improved methods of harvesting and management for farm fuelwood forestry are a few other examples of key areas of suggested research priority for the coming decade. In relation to industrial forestry, an important area for intensified research is into prospects for making more effective use of secondary hardwoods.

Because a high proportion (over 70%) of the reforestation needed in developing countries in the coming two decades will be on farmlands and agricultural wasteland, support for agroforestry research into the scope for incorporating trees into farming
systems is another priority area of concern. The work of ICRAF* in Nairobi and CATIE in Central America is concerned with that issue.

**Brazil: A Case Study of Forestry Research at Aracruz Florestal**

The story of the Aracruz Florestal company in Brazil is perhaps one of the most successful industrial forestry operations in the tropics.

Aracruz Florestal S.A., is a privately owned forest company which manages 85,000 ha in northern Espirito Santo and southern Bahia in Brazil. Approximately 60,000 ha of plantation composed of several species of eucalyptus provided the raw material for a mill producing 450,000 T of bleached pulp per year.

The company was started and the first plantations established in 1967. The initial planting programme was supported in part by the Forestry Incentive Programme, which allows a portion of Federal income tax to be used for certain forestry programmes. This government programme has encouraged plantation establishment and has been instrumental in the development of much of Brazil's current forest industry.

Aracruz was a pioneer in large-scale plantation forestry in the region. Information on which to base its choice of plantation species was practically non-existent and silvicultural information was limited to research on eucalyptus by government organisations and private forest companies in the state of Sao Paulo. Due to different ecological conditions at Aracruz, technologies developed in Sao Paulo on such things as spacing, fertilisation and weed control, however, were not directly applicable. In addition, the provenances, especially of *E. saligna* and *E. grandis* brought from Sao Paulo were not well adapted to Espirito Santo and many trees died when attacked by an exotic canker whilst others suffered damage from insects and disease. In 1972 Aracruz formed a research team with emphasis on tree improvement, soils and nutrition, and pathology in order to find solutions to these and other problems.

This research team currently consists of six professionals — two in tree improvement and pathology, and one each in entomology, soils and nutrition, and applied statistics. The team is supported by 70 technicians, aids and field workers.

In 1974, as part of a tree improvement programme aimed at increasing yields and producing more homogeneous planting material, Aracruz initiated a research programme on vegetative propagation of eucalyptus. Initial propagation studies were successful. Clonal orchards were established and in 1979, the first commercial planting of clonal material was made (approximately 1 M rooted cuttings). The number planted increased successively from 3.5 M in 1980 to 10 M in 1983. The projected planting for 1984 is approximately 15 M cuttings, or essentially 100% of the company's current planting programme.

Gains made through the use of clonal material have been spectacular. Average increment has increased 112% (from 33 to 70m³/ha/yr). Average wood density has increased by 25% and cellulose content by 23%. All clones currently in use are so far resistant to the major diseases affecting eucalyptus in the area (*i.e.* canker, rust, foliage diseases). The plantings of individual clones are extremely homogeneous in growth rate, and mortality due to over-topping of slower growing trees does not occur as was the case in plantations established from seedlings. Since clones were selected partially for their ability to coppice, the percentage of stumps that coppice following the first and subsequent harvests approaches 100%.

To achieve these results, Aracruz has invested about 12% of its annual forestry budget...
in forest research over the last decade. The research programme has already paid for itself many times over.

In 1984, the Aracruz Company won the prestigious Marcus Wallenberg Prize for pioneering work in forestry industry research.

**Institutional Strengthening, Training and Extension**

The point was made at the outset of this paper that investment in forestry development programmes cannot succeed unless there is simultaneous provision for institutional strengthening in training, research and extension. Investment in such components in past development bank funded projects comprised between 15 and 25% of total development costs. Yet lack of trained manpower remains the main constraint to progress in almost all developing country forestry programmes. Nevertheless, there are many examples of situations where political commitment to resolving this bottleneck has been successful in providing a nucleus of well trained staff. To conclude this discussion of case studies of successful projects, here are a few examples of what can be achieved given government commitment and adequate investment in institution building:

Forty years ago there were few, if any, forestry training institutions in Latin America; today several countries have high quality training institutions (e.g. Brazil, Argentina, Chile, Peru, Costa Rica) and Latin America has some important regional institutions (e.g. CATIE, ESNACIFOR).

Africa had no professional training institutions twenty-five years ago; Mweka and Garoua, regional schools established to fill the gap, have trained over 1,500 wildlife managers who now serve in parks throughout Africa, and have stimulated increased support for park designation and establishment of national training institutions. Mweka has served as a model for other wildlife management schools in Africa and one in Indonesia.

The Department of Forestry at the University of Ibadan, Nigeria, established in 1963 with the assistance of UNDP and FAO, has built a reputation as a strong national professional training institution and has trained over 1,000 graduates.

ESNACIFOR, the only institution in the Central American region that provides technical level forestry training, has graduated over 500 students, provided numerous short courses and seminars, and built a strong reputation for its academic standards since its establishment in 1969. Although currently suffering from financial difficulties, it has the potential of being self-supporting financially, and could continue to meet the need for middle-level forest technicians in the region.

Twinning relationships between universities have proven a successful strategy of training (e.g. University of Aberdeen and University of Malaysia, etc.).

Extension has been a major and essential component of successful forestry projects in fuelwood and social forestry (Korea, China, India), watershed management (India, Nepal, Ethiopia), and some industrial forestry projects (PICOP).

Forestry extension in Nepal’s Community Forestry Programme was an essential factor in the successful mobilisation of farmers to carry out tree planting.

**An Action Programme for the Future**

The earlier sections of this paper have set out to demonstrate that there are many successful past experiences of investment projects in forestry that can provide a solid
basis for replicated action on a larger scale. Secondly, that such projects are capable of earning attractive economic rates of return.

In looking to the future perhaps the most encouraging development that has taken place in 1985 is that in response to FAO's Tropical Forest Action Plan, many national government leaders, leading international development agencies and environmental groups have been able to reach broad agreement; firstly, on which deforestation issues should be most urgently addressed; secondly, on which countries are most urgently in need of assistance; and, third, on what would be the broad order of investment requirements that would be needed to make a significant impact on these issues.

The principal documents which set out such an Action Programme are those already submitted to the World Forestry Congress in July of this year by FAO's Committee of Forest Development in the Tropics which gave a global perspective for the coming decade, and a joint World Resources Institute/World Bank/UNDP study which examined case studies of past development projects and suggested an Accelerated Investment Programme for 58 priority countries for the coming five years.

In projecting those investment requirements, an attempt was made to take into account likely absorptive capacity as this would be influenced by the current levels of receptivity of local populations to forest conservation and tree planting programmes and

Table 5
An accelerated programme for containing tropical deforestation in 58 priority countries
(See Annex 2 for country details)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Watershed Management and Desertification Control</th>
<th>Industrial Forest Conservation and Management</th>
<th>Agroforestry and Ecosystem Conservation</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watershed Management</td>
<td>400</td>
<td>250</td>
<td>131</td>
<td>1087</td>
</tr>
<tr>
<td>Fuelwood</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asia</td>
<td>907</td>
<td>725</td>
<td>160</td>
<td>3132</td>
</tr>
<tr>
<td>Agroforestry and Conservation</td>
<td>575</td>
<td>725</td>
<td>272</td>
<td>1747</td>
</tr>
<tr>
<td>Desertification</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Latin America</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>1882</td>
<td>1700</td>
<td>563</td>
<td>5966</td>
</tr>
<tr>
<td>(32%)</td>
<td>(31%)</td>
<td>(28%)</td>
<td>(9%)</td>
<td>(100%)</td>
</tr>
</tbody>
</table>

Assuming that these 58 countries represent about 75% of total developing country investment needs, it implies the total 5 year requirement of something in the order of US $8 billion.

Based on a crude comparison of past relationship and taking into account the need for accelerated investment in priority countries.
the strength of existing government agriculture, forestry, energy and other institutional extension support services.

Table 5 details of which appear in Annex 2, summarises the investment needs by developing country regions for the coming five years. They amount to a total of US $8 billion of which almost one-half would be sought from external aid sources. That constitutes roughly a doubling of the current level of official aid, grant aid and investment flows to forestry. Of the US $8 billion about US $6 billion (i.e. 75%) would be needed for the 58 priority countries reviewed in the World Resources Institute study and the balance is a rough estimate of the needs of the remaining countries not listed in that programme.

Most importantly, this Programme would aim to broaden the emphasis of past investment to include stronger support from outside the forestry sector (particularly agriculture) for measures that would provide farmers living in over-populated watersheds, areas threatened by desertification and in forest lands situated adjacent to unique forest ecosystems with an alternative to further forest encroachment.

Of the total five year priority country investment programme needs of US $8 billion, about US $1.8 billion or about 30%, would be primarily agriculture related investment.

Assuming that 50% of the total investment target of US $8 billion suggested above for all Third World countries were to be met from external aid sources, the level of external aid support required would be about US $800 M a year. That still represents a relatively small proportion (less than 2%) of total 1985 official development assistance to Third World Countries.

Of the 58 countries involved in the Action programme, 16 are Commonwealth countries, the investment requirements of which would amount to US $1.8 M or 30% of the total programme.

Given political will, part of the local investment required could be met by reallocation of national government development priorities to give greater emphasis in the immediate future, to problems of deforestation and environmental concern. Perhaps the most outstanding example of political leadership in this century which did precisely that, was the action taken by the late Mrs. Indira Ghandi in her final year of premiership in India. Largely because of her personal interest in forestry and environmental issues and her many public statements of commitment to addressing those problems, India’s agriculture, forestry and economic planning ministries responded in a very positive way.

In the Seventh (i.e. current) Plan period, the proportion of agriculture sector investment to be allocated to social forestry and watershed protection in India has more than doubled. What has emerged from this initiative is a national programme of social forestry and watershed rehabilitation on a scale unequalled anywhere else in the developing world except China.

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## Developing Countries Most Affected by Deforestation

<table>
<thead>
<tr>
<th>Countries with Serious Fuelwood Shortages</th>
<th>Countries with Significant Areas of Deforested Watersheds</th>
<th>Countries Experiencing Desertification Problems</th>
<th>Countries in Which Industrial Forest Protection and Management Need Reinforcement</th>
<th>Countries Which Contain Unique Forest Ecosystems that are Threatened with Extinction</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFRICA</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Botswana</td>
<td>Ethiopia</td>
<td>Burkina Faso</td>
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<td>Cameroons</td>
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<tr>
<td>Zimbabwe</td>
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| ASIA                                      |                                               |                                               |                                               |                                               |
| Bangladesh                               | China                                         | India                                        | Burma                                         | India                                         |
| China                                    | India                                         | Nepal                                        | China                                         | Indonesia                                     |
| India                                    | Nepal                                         | Pakistan                                     | India                                         | Malaysia                                      |
| Nepal                                    | Pakistan                                      | Philippines                                  | Indonesia                                     | Philippines                                   |
| Pakistan                                 | Philippines                                   | Thailand                                     | Malaysia                                      | Thailand                                      |
| Philippines                              |                                                 |                                               | Pakistan                                      |                                               |
| Sri Lanka                                |                                                 |                                               | Papua New                                     |                                               |
| Thailand                                 |                                                 |                                               | Guinea                                        |                                               |
|                                           |                                               |                                               | Philippines                                   |                                               |
|                                           |                                               |                                               | Thailand                                      |                                               |

| LATIN AMERICA                             |                                               |                                               |                                               |                                               |
| Bhutan                                    | Brazil                                        | Colombia                                     | Argentina                                     | Belize                                        |
| Brazil                                   | Colombia                                      | Ecuador                                      | Brazil                                        | Bhutan                                        |
| Chile                                    | Ecuador                                       | Haiti                                        | Chile                                         | Brazil                                        |
| Colombia                                 | Haiti                                         | Panama                                       | Colombia                                      | Colombia                                      |
| Ecuador                                  | Panama                                        | Peru                                         | Costa Rica                                    | Costa Rica                                    |
| El Salvador                               | Peru                                          |                                               | Ecuador                                       | Ecuador                                       |
| Guatemala                                |                                               |                                               | Guatemala                                     | Guyana                                        |
| Haiti                                    |                                               |                                               | Jamaica                                       | Nicaragua                                     |
| Jamaica                                  |                                               |                                               | Mexico                                        | Panama                                        |
| Mexico                                   |                                               |                                               | Peru                                          | Peru                                          |
| Peru                                     |                                               |                                               | Venezuela                                     | Suriname                                      |
|                                           |                                               |                                               |                                               | Venezuela                                     |
## AN ACCELERATED INVESTMENT PROGRAMME FOR ADDRESSING ISSUES OF DEFORESTATION IN DEVELOPING COUNTRIES

Estimated Investment Requirements\(^1\) 1987–1991 (US$ Millions)
(Including overseas development assistance (ODA), private sector\(^2\), and contributions of national governments and local farmers and communities\(^3\)

<table>
<thead>
<tr>
<th>Region/Country</th>
<th>Watershed Management and Agroforestry (5 years)</th>
<th>Industrial Forestry(^5)</th>
<th>Agroforestry Ecosystem Conservation(^6)</th>
<th>Country Total (5 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agroforestry Fuelwood(^7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AFRICA</td>
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<td><strong>250.0</strong></td>
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\(^1\) Estimated investment requirements for 1987–1991 (US$ Millions)
\(^2\) Including overseas development assistance (ODA), private sector contributions
\(^3\) Contributions of national governments and local farmers and communities
\(^4\) Region
\(^5\) Country
\(^6\) Fuelwood
\(^7\) Watershed Management and Agroforestry Desertification Control
\(^8\) Industrial Forestry
\(^9\) Agroforestry Ecosystem Conservation
### Annex 2—(Contd)

<table>
<thead>
<tr>
<th>Region/Country</th>
<th>Agroforestry Fuelwood</th>
<th>Watershed Management and Desertification Control</th>
<th>Industrial Forestry</th>
<th>Agroforestry Ecosystem Conservation</th>
<th>Country Total (5 years)</th>
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<td>—</td>
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<td>(500.0)</td>
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<td>18.0</td>
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### Annex 2 (Contd)

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<th>Region/Country</th>
<th>Agroforestry Fuelwood</th>
<th>Watershed Management and Desertification Control</th>
<th>Industrial Forestry</th>
<th>Agroforestry Ecosystem Conservation</th>
<th>Country Total (5 years)</th>
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</thead>
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<tr>
<td>Peru</td>
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<td>20.0</td>
<td>30.0</td>
<td>36.0</td>
<td>110.0</td>
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<td>Suriname</td>
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<td>GRAND TOTAL</td>
<td>1882.0</td>
<td>1821.0</td>
<td>1700.0</td>
<td>563.0</td>
<td>5866.0</td>
</tr>
<tr>
<td></td>
<td>(32%)</td>
<td>(31%)</td>
<td>(28%)</td>
<td>(9%)</td>
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</tbody>
</table>

---

1. Definition of investment includes institution building, research and technical assistance which usually comprises between 15–25% of total investment needs.

2. For broad planning purposes, past experience suggests that about 50% of total investment requirements would be met from external aid sources.

3. This study is based on analysis of 58 priority countries that were selected mainly on the basis of FAO studies that have examined countries most severely affected by fuelwood shortages, water catchment degradation, desertification and inadequate conservation. This is no way implies that investment should be channeled only to those countries — they were selected mainly because in the short term, they are those countries most urgently in need of assistance.

4. Treated concurrently because much of the fuelwood required will be established as an integral part of agroforestry planting programmes.

5. Predominantly agricultural investment in which forestry plays a critical but supporting role.

6. Refers only to forest reserve management and protection and excludes industrial processing.

7. Of which 80% would be agriculture investment aimed at taking the pressure off threatened forest areas and the balance investment in scientific research, national park development and protection.

8. The investment requirements of China, India and Brazil dominate the programme. They account for 40% of total investment needs.
### Analysis of Development Aid Assistance to Forestry

#### Annex 3

**Table: Assistance to Forestry (US$ millions)**

<table>
<thead>
<tr>
<th>Agency</th>
<th>Annual Development Assistance</th>
<th>Percentage of total in Forestry</th>
<th>Annual Development Assistance (Agriculture)</th>
<th>Percentage of Agric. for Forestry</th>
<th>Total Forestry Investment</th>
<th>Estimated Average Annual Investment in Forestry</th>
<th>Source of Data</th>
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<td><strong>MULTI-LATERAL FINANCING</strong></td>
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<tr>
<td>World Bank</td>
<td>15,000</td>
<td>0.8%</td>
<td>3,500</td>
<td>3.4%</td>
<td>1061</td>
<td>1967–1984</td>
<td>106</td>
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<tr>
<td>Inter-American Development Bank (IDB)</td>
<td>3,000</td>
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<td>-</td>
<td>-</td>
<td>74</td>
<td>1975–1984</td>
<td>8</td>
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<tr>
<td>Asian Development Bank (ADB)</td>
<td>615</td>
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<td>305</td>
<td>6.5%</td>
<td>151</td>
<td>1977–1984</td>
<td>19</td>
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<td>United Nations Development Programme (UNCP)</td>
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<td>-</td>
<td>250</td>
<td>1966–1984</td>
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<tr>
<td>Food &amp; Agriculture Organisation (FAO)</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>12</td>
<td>1982–1983</td>
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<tr>
<td>World Food Programme (WFP)</td>
<td>25</td>
<td>40%</td>
<td>-</td>
<td>-</td>
<td>192</td>
<td>1963–1984</td>
<td>10</td>
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<tr>
<td>African Development Bank</td>
<td>500</td>
<td>0.8%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
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<tr>
<td>Organisation of American States (OAS)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5.4</td>
<td>1984–1985</td>
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**Sub-total Multilateral Financing Agencies** | $175 |
<table>
<thead>
<tr>
<th>Agency 1</th>
<th>Annual Development Assistance 2</th>
<th>Percentage of total in Forestry</th>
<th>Annual Development Assistance (Agriculture) 3</th>
<th>Percentage of Agric. for Forestry</th>
<th>Total Forestry Investment 4</th>
<th>Period</th>
<th>Estimated Average Annual Investment in Forestry</th>
<th>Source of Data</th>
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<tr>
<td><strong>Group I — BILATERALS</strong>&lt;br&gt;(over $25 million/yr)</td>
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<tr>
<td>Canadian International Development Agency (CIDA &amp; IDRC)</td>
<td>650</td>
<td>7.5%</td>
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<td>—</td>
<td>208</td>
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<td>45</td>
<td>FAO, 1984</td>
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<td>Swedish International Development Agency (SIDA)</td>
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<td>8.3%</td>
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<td></td>
<td>35 7</td>
<td>Corresp. SIDA 1985</td>
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<td><strong>Sub-total—Group I</strong></td>
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<td><strong>Group II — BILATERALS</strong>&lt;br&gt;($10–15 million/yr)</td>
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<td>France (FAC/COCE)</td>
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<td></td>
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<td><strong>Subtotal — Group II</strong></td>
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<td>$60</td>
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<table>
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<th>Agency</th>
<th>Estimated Annual Average in Forestry</th>
<th>Source</th>
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<td>Group III — BILATERALS (10 million/yr) Australia, Belgium, Finland, Denmark, Norway, New Zealand, OPEC</td>
<td>US$35M</td>
<td>FAO, 1984, USDA, 1980</td>
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### Total All Agencies

<table>
<thead>
<tr>
<th>Annual Development Assistance</th>
<th>% used for Forestry</th>
<th>Estimated Annual Average Investment in Forestry</th>
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<tr>
<td>Multilateral Financing and Groups I, II and III</td>
<td>US$30,000M</td>
<td>1.3%</td>
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</table>

1. Does not include PVO/NCO and private sector financing.
2. Estimate of average annual lending (grants and loans), for all sectors.
3. Includes agriculture, rural development and forestry.
4. Includes forest management, reforestation, agroforestry, and wood energy; does not include investments for paper and pulp industrial processing and all regional or worldwide supporting programmes.
5. Does not include capital investments for pulp and paper processing.
6. Adjusted to include estimated forestry financing from PL 480.
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FINANCING FORESTRY

By B. I. Howe

SUMMARY

The president of a major British Columbian timber using corporation explains that industry does not have the funds for reforesting public owned lands. There is the expertise to establish and manage the forest, there is skilled labour at present unemployed but not receiving financial help from the government. A reallocation of government spending could ensure that the forest resource was sustained, that constructive employment could be enjoyed and government money spent on forest establishment would show both immediate and long term benefits. Providing that there was a commitment from those who own the forest resource, those who utilise the produce from the forest and those whose work affected each stage from the young tree to the finished product, the investment of public funds and private capital would generate worthwhile returns for all involved.

RESUMÉ

Le président d'une corporation de Colombie britannique qui est une utilisatrice importante de bois d'oeuvre explique que l'industrie ne dispose pas des fonds nécessaires aux reboisement des terrains du domaine public. On dispose de l'expertise d'établir et de gérer la forêt, et il y a de la main-d'œuvre professionnelle maintenant au chômage. Une nouvelle répartition des dépenses gouvernementales pourrait assurer le maintien de la ressource forestière, fournir du travail productif et assurer que des deniers gouvernementaux dépensés pour établir la forêt montreraient des bénéfices et immédiats et a long terme. Pourvu qu'il y eût un engagement de la part des propriétaires de la ressource forestière, des utilisateurs des produits forestiers et de ceux dont le travail influence chaque étape du semis jusqu'au produit fini, l'investissement des fonds publiques et du capital privé serait très lucratif pour tous les intéressés.

RESUMEN

El presidente de una importante empresa maderera en British Columbia explica que la industria no tiene fondos para la reforestación del terreno público. Existen los conocimientos para el establecimiento y el manejo del bosque, lo mismo que mano de obra calificada, actualmente desempleada y recibiendo ayuda financiera por parte del estado. Una mejor distribución de los gastos del gobierno podría asegurar el sostenimiento del recurso forestal y la creació de nuevas fuentes positivas de empleo dedicado a la reforestación, lo cual traería beneficios tanto a corto como a largo plazo. Siempre y cuando haya un compromiso por parte de los dueños del recurso forestal, de los que aprovechan los recursos forestales y de los que estan involucrados en cada etapa desde el arbol joven hasta el producto final, la inversión de fondos públicos y privados proporcionaría apreciables beneficios para todos los interesados.

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# Introduction

The forest industry around the world is undergoing substantive change: new technology is altering the way goods are produced, new products are replacing established ones, new producers are entering world markets and redefining long established trading relationships.

It is most appropriate that the 12th Commonwealth Forestry Conference should be held in Canada, in particular in British Columbia where the forest community is crossing its own threshold of change. The development of traditional methods for forest harvesting and renewal appears to have reached a plateau providing inadequate regeneration. The establishment and management of sufficient young trees to sustain the supplies for industry and in turn the contribution made to the country's economy will require an increased amount of investment. Quick and appropriate regeneration of the forest will cost money. Where will this money come from and who pays for it? The author's credentials for attempting to answer these questions stem from being president of the British Columbia Resources Investment Corporation, a diversified resource company which includes among its operating divisions one of British Columbia's larger forest companies, Westar Timber. This operates in both the main streams of forest products, in both lumber and pulp. In 1984, the five sawmills produced 548 M board feet of lumber and the two pulp mills shipped 383,000 T of market pulp. Under the Province's forest management system, the company's annual allowable cut exceeds 3 M m$^3$. Forest tenure is under Forest Licences and Tree Farm Licences, two of the latter, one in the north west and one in the south east, cover a combined area of over 1.5 M ha — about the size of Wales.

## The Business climate

Since 1981, Westar Timber, along with other forest product companies, has faced a grimly challenging business environment. The world market is oversupplied with both pulp and lumber and depressed prices reflect the imbalance between supply and demand. In the years leading up to the recession, the industry incurred substantial debts to finance modernisation and expansion of capacity. Trading losses aggravated the debt, leaving much of the Canadian forest industry short of money. Over the past few years, the industry's mind has been appropriately concentrated, not on questions of long-term resource development, but on the issue of immediate survival.

When a farmer is being hit from all sides by blight, insect damage and pointed questions from the bank, he has little time to consider the state of his land ten or twenty years ahead. However, notwithstanding immediate problems, the planting of the seed corn to yield the future crop achieves a priority which cannot be neglected. For Canada's forest farmers, that time has now arrived. The timber industry is so obviously of importance to the Canadian economy that the justification for investment should be apparent, but historically, there has been a reluctance to spend money on forestry by both government and the individual. Canadian export earnings from the forest sector exceed the combined significance of mining, agriculture, manufacturing and fisheries; one in ten Canadian workers is employed by an industry associated with the forests. The harvesting of the forests has paid insufficient attention to their renewal. The time has now arrived to reverse the trend of decreasing forest growing stock. The money to fund this type of investment can come from private sources or from government, either from within a country or from outside or from two or more of the four combinations.

One of the pertinent factors when considering forest investment in Canada, or in
particular British Columbia, is that the main owner of the resource is the provincial crown. The right to harvest is granted under a tenure system to forest companies by the Ministry of Forests. Tenure is not permanent. Operating companies must fulfil certain obligations. The chief of these is that the resource must be used to generate economic activity benefitting the public. To meet this obligation and to remain in business, the industry has made considerable investment in milling and transportation. Jobs have been created and the government enjoys substantial tax revenue.

Companies also pay royalties and leasing fees and after felling, undertake reforestation work through contractual agreements with the Crown. In effect, the industry is paid to replant the timber it harvests. If the same company should still be operating at the end of another rotation, it will still pay fees, taxes and royalties for the right to harvest. The trees belong to the people of British Columbia. If the industry were to be asked to fund reforestation, this would be like requiring a leaseholder to pay for capital improvements to a house he is only renting. The real owners of the forest resource, the people, are mostly unaware of the nature of the partnership between the public and private sectors. This lack of understanding has been the source of some friction. However, the public, the government and the private sector all have an interest in helping the forests maintain their role as major providers of employment and this in turn depends upon the industry being able to sell timber at competitive prices on the international market. All other questions aside, the fact remains that the industry can not afford to take on the burden of financing reforestation; it does not have the money.

The prospect

If we accept that the responsibility for growing and managing the forest rests with those who own the resource, recent announcements suggest that there should be substantial improvements. In British Columbia, the provincial and federal governments will spend $300 M over the next five years on planting and silviculture. This joint Forest Resource Development Agreement of May, 1985 will maintain some 500 full-time jobs and generate short-term employment for over 15,000. The planting programme between 1985 and the end of the ’86 season will include 200 M seedlings. This compares favourably with 65 M in 1975 and only 18 M in 1965. Forest Management will increase the productivity of stocked areas: approximately 150,000 ha of young stands will receive spacing and fertiliser treatment and other 37,000 ha will receive weeding, brashing and pre-commercial thinning. The five-year programme of work demonstrates the commitment of the federal and provincial governments to the renewal of the forest resource: this is in the interests of those who are responsible for the industry, for those who work in the woods and in the mills.

Whilst it is recognised that the revenues from the forest sector pay for social services such as health care and education, the fraction which has been ploughed back into the resource has proved inadequate. More money is required if the resource is not to be depleted further. If more is to be spent, which particular facet of the economy will make the contribution? The industry is already paying as much as it can afford and still be viable and competitive: increasing general taxation can be counter productive, neither is increased government borrowing a permanent solution. It is possible though, for the money to be allocated from existing government spending programmes. It is not enough to justify spending on forestry by some anticipated benefit to a future generation, the politics of the situation demand that the government can demonstrate that spending today will benefit society today. Luckily for the forest community, it can.
The rationale

Canada is beset with drastic levels of unemployment. The official rate for British Columbia is about 13%, the unofficial rate including those who have given up seeking work is probably closer to 20%. Many of these people have had experience in the forest industry. Not only is there an enormous direct cost of unemployment and social welfare benefits but the government is also deprived of income from consumer and personal taxation. The opportunity is obvious: combine the need of the unemployed for jobs with the need to restock and improve the forest areas. The emphasis of the programmes already undertaken has been on job-creation with the benefits to forestry being ancillary. These should be reversed with forestry being the priority and job-creation the supplementary benefit. Once the public appreciate that the regeneration of the forest is an industry in its own right, the jobs which appear will become permanent.

Implementation

If the government is willing to accept the responsibility for funding forest renewal, the private sector would invest its expertise to produce the results. The financing can come initially from the funds governments are now allocating to maintain the unemployed. This contribution would be returned by reductions in present spending and by revenues generated from income and retail taxes. The new forest establishment industry could be sustained by innovative tax incentives to encourage investment in road construction, planting, maintenance and silviculture. The federal government used a grant programme to encourage oil and gas exploration. A Forestry Improvement Programme might mirror the Petroleum Incentive Programme with grants correlated to job creation. If it made sense to encourage the development of an ultimately finite resource, it should be even more worthwhile for one which can benefit future generations in perpetuity.

Westar Timber has proposed a pilot silvicultural project for its timber lands in the depressed area around the town of Terrace in northwestern British Columbia. The renewal of the forest is a necessity. It need not be considered a problem or a threat but can be considered as an opportunity; the establishment and tending of the young forest can become a thriving and worthwhile business.

Conclusion

There are available the foresters who appreciate and can supervise the work entailed in forest renewal. There are unemployed people, many of whom have the appropriate competence, who have an enthusiasm to participate. Existing government funds can be reallocated. The private sector has funds which, with incentives from the tax system and a commitment from government and labour, would be invested in the renewal of the forest and its infrastructure. All sections of the community will prosper and in addition to the country having goods to export at competitive prices, there will be Canadian expertise which can help other countries overseas solve their own problems associated with forest creation and management.
MAKING THE BEST OF INVESTMENT RESOURCES

By P. M. SOUTH

SUMMARY

International gatherings of foresters in recent years have concentrated somewhat on forestry’s potential to improve the quality of life of humankind, particularly the populations of post-colonial and other lesser-developed countries.

Philosophical concepts which have been advanced with increasing vigour are:
- forests provide a base from which to launch attacks on economic underdevelopment; providing they are well planned, investments in forests can be justified because of their manifold socio-economic and other benefits, in almost any circumstance.

Clearly these propositions have their own validity and it is tempting to allow them to outweigh other more practical considerations which, on the surface at least, may seem less altruistic.

However, it seems to be that if an investment in forestry is made for no other reason than that land is available, it is likely that the return on funds would be less than optimal, and inefficient in the use of the investment resource.

The evidence is that the more successful forestry project is characterised by the clear definition of the investor’s objectives and the objectivity of its pre-planning.

Where this occurs, the achievement of a successful crop is not seen in every case as an end in itself; very often the ultimate objective is its profitable utilisation by a forest owner, integrated to the maximum extent and aimed primarily at ensuring such a return on funds as would encourage further investment.

RESUME

Les réunions internationales récentes de sylviculteurs se sont concentrées quelque peu sur le potentiel de la sylviculture d’améliorer la qualité de la vie de l’Homme, surtout les populations d’anciennes colonies et d’autres pays sous-développés.

Les concepts philosophiques qui ont été proposé avec de plus en plus de force sont: que les forêts fournissent une base de laquelle on pourrait commencer à lutter contre le sous-développement; pourvu qu’ils soient bien conçu, les investissements en forêts peuvent être justifiés à cause de leurs multiples bénéfices socio-économiques, etc., en presque tout état de cause.

Evidemment ces propositions ont leur propre force, et il est tentant de les laisser l’emporter sur d’autres considérations plus pratiques qui sont en apparence moins altruiste.

Pourtant, il paraît que si un investissement en sylviculture est fait simplement parce que cette terre est disponible, il est probable que le rendement des fonds serait moins qu’optimal et inefficace dans l’utilisation de la ressource d’investissement.

Il est évident que les projets forestiers les plus réussis sont caractérisés par la définition précise des buts du capitaliste et l’objectivité de sa conception d’avance.

Où cela arrive, l’atteinte d’une culture réussie n’est pas toujours considérée comme un but en soi; très souvent l’objectif ultime est son utilisation lucrative par un propriétaire forestier, intégrée au maximum et visée premièrement à assurer un rendement des fonds de façon à encourager plus d’investissement.
Las reuniones de forestales en los últimos años se han concentrado hasta cierto punto en el potencial de la selvicultura de mejorar la vida humana, particularmente la de los habitantes de pueblos post-coloniales y de otros países menos desarrollados.

Las ideas filosóficas que se han presentado cada vez con más fuerza son:

Los bosques proveen la base de donde atacar el subdesarrollo económico.

Con tal de que estén bien planeadas, las inversiones en bosques se pueden justificar por muchos aspectos socioeconómicos y otros beneficios, casi en cualquier circunstancia.

Está claro que estas proposiciones son válidas y es tentador permitir que preponderen sobre otras consideraciones más prácticas que, al menos a primera vista, pueden parecer menos altruistas.

Sin embargo parece ser que si se invierte en selvicultura simplemente porque hay tierra disponible para ello, lo más probable es que las ganancias no sean óptimas ni eficientes en cuanto al uso de los recursos invertidos.

La evidencia es que los proyectos forestales más eficaces, se caracterizan por la clara definición de las miras del inversor y por la objetividad de su pre planificacion.

Cuando éstos ocurre el conseguir una buena cosecha no se considera siempre como una meta por sí misma. Con frecuencia la meta final es el uso provechoso de los beneficios obtenidos por el dueño del bosque, integrados al máximo y enfocados especialmente para asegurar una retribución de fondos que incite a más inversiones.

**Introduction**

It would be hard, I believe, to name a forester who would not argue for expanding the forest resource, even if only in principle. More than others, foresters are aware of the many and diverse benefits which flow from the forests to mankind, and at the same time they see declining *per capita* availability of these benefits as a probability, if not a certainty. Our education, training and experience convince us that it is a benefit to the community to grow trees: two trees are better than one, and two million is better than one million.

The profession has been sounding the alarm about deforestation for generations and it is no longer necessary to make a popular case for the growing of the world’s wood. Nowadays, most of us are confident and even smug about this: in a world of finite resources, the forest is renewable and, ignoring its other benefits, its conversion into useful commodities and products is less energy-demanding and less damaging to the environment than that of the metal and other extractive industries. In other words, it would be hard to go too far wrong if we grow a forest, no matter where, and at what cost. If we accept this proposition, and very many of us do, it would be to believe that there are no bad investments in forestry but some may be better than others. If so, it would be useful to spell out those elements which make one better than another, perhaps even to arrive at a formula which would apply with equal force in all circumstances. If only this were possible! The combinations and permutations are many, too many for it to be possible only to outline the essentials. Foresters at the 12th Commonwealth Forestry Conference would have to agree to disagree very substantially on important matters of principle on where best an investment should be made, before even thinking about how to make it.

**Forest policy**

The forests we are managing or would like to grow are as varied as the climates in which they occur and these are no less dissimilar than the economies and social conditions of
the communities which utilise them. Some, for example, would opt for intensified management of an existing resource while others would want to establish plantations of fast-growing exotics. It is no surprise that the needs and priorities of a less developed country, politically still organised mainly around the village, should differ from others, urbanised and industrialised, incredibly affluent by comparison. Among the developed countries, the political philosophy of the government of the day affects the nature and extent of investment at any one time. Forestry projects generally are based on political decisions, with wood production for industry the principal aim. They have been funded mostly by or for governments and, perhaps because of the long-term nature of growing a wood crop, too often the financial integrity of the project has been left in the air. Depending on the date of elections, some governments are committed totally to private enterprise and the unfettered play of the free market. Others favour a mixed economy where the role of State and private enterprise is defined more pragmatically. It is common also for other politically sensitive components, local employment, tourism, infrastructures, etc. to attach themselves, each with its own benefits and costs, but which seldom have been defined sufficiently or given their own priorities. Although nowadays there are notable exceptions, investments in afforestation either by regeneration or by plantation establishment generally have been on publicly-owned lands and almost always a strong element of subsidy is to be observed. Governments balance the benefits which accrue (and this may include votes) against calls on its funds for education, health, defence and other socially desirable programmes. Country by country, the return to the forest owner on sales of industrial roundwood from publicly-owned forests is geared to world wood prices; in some cases this barely covers the cost of arranging its sale to processors and generally it is less than the cost of its replacement. Similarly, private investment in plantation forestry is encouraged in some countries with balance of payment difficulties, by various incentives and subsidies which allows their wood and wood products to compete on world markets. In these circumstances, if an investment is to have a hope of achieving its purpose, or even for an assessment to be made of the merit of its results, there should be a precise declaration of all its aims. In my terms this would begin with a forest policy statement which would affirm, without hyperbole (and all other incidentals aside), that to achieve a surplus on funds employed is the purpose of the investment; in plain terms, make a profit. No matter whether it is by a public agency or by any combination of private and State enterprises and entrepreneurs, this intent should be stated. How this profit is measured would vary according to the principal aim of the forest owner. It could be calculated by increased yields at lower costs of water, tourists, or other forest products (fuel, fruits, sawlogs). For those communities affluent enough to accept the costs, recreational access to forests and other more ephemeral aesthetic benefits could be the criteria. It may well be that (as in South Australia), the objective is to supply the community's wood needs at competitive prices without subsidy or other calls on the public purse, on a sustained yield accounting basis. What is important, however, is for the forest manager to be able to demonstrate to the provider of funds that he is aiming successfully at an agreed-upon target and a long-term investment was, and is, justified.

Examples of this sort of approach are encountered in industrial forestry production complexes which have emerged during the last fifty years in some developed countries in the western and southern hemispheres. Whether privately or State-owned, they have abandoned the older perception of the forest owner solely as a grower of trees for sale to conversion industries on a commodity auction basis. They manage their timberlands, plantations or naturally-occurring, to produce agro-industrial crops as raw material for the integrated production of wood products; acting themselves as the processor, they are better able to ensure a return to the forest which justifies the cost of growing it. It is not
inferred that all forestry investments should or need to follow this example. However, and this does not exclude altogether those which are aimed at providing fuelwood for cashless communities, there are principles here that can be applied, even if only in part, with benefit to most schemes.

Forestry Investments — Self Sustaining Enterprises?

It should be noted that I am not talking here about fuelwood, in famine areas in the Third World, where desperate needs may demand desperate measures. Their discussion would cloud the more dispassionate points I would like to make on forestry investments appropriate for more developed countries.

As suggested earlier, an investment has a better chance of success when its progress can be monitored and its final result measured against a clearly defined goal which can be called, to my satisfaction anyway, a profit. This may appear to imply that the intending forest investor needs a range of skills which includes clairvoyance if he is to be capable of preparing a realistic budget which must depend on supply and demand predictions some generations hence. Not only should there be the professional competence to select suitable sites, species, provenances and silvicultural treatments for a successful tree crop but also, almost mystically, to make an acceptably accurate estimate of the future level of world prices for forest produce. There is no need to spell out the difficulties that were in the way of putting all these skills together in the past; the variables in the supply and demand equation alone, were almost infinite. However, the record of the last few centuries shows a progressive reduction in the imponderables which used to make the determination and administration of forest policies more of an art than a science.

There are many projections which, although differing considerably in detail, precision and range, when taken together indicate a trend upward in demand, and downward in supply: expanding world population and its increasing urbanisation, together with unabated deforestation are but some of the factors which appear to make this inescapable. Then there is the knowledge that forest clearance in the western countries, now well advanced, will exert an effect which goes beyond simple supply and demand. Comparatively speaking, little remains of the readily-accessible preferred softwoods and hardwoods from virgin forests which have dominated world trade in wood since the beginning of the colonial era. Their utilisation essentially was a mining operation and, relatively speaking, little of the capital which accumulated from their exploitation was reinvested in their renewal. Regarded by their fortunate possessors as ‘free goods’, they were used profligately for local consumption, with surpluses exported at prices which reflected their no-cost establishment. Most often, and especially in periods of world economic downturn, the price accepted by exporters of forest products has been less than the cost of production in importing countries. Those days have passed or are passing. More and more it is becoming clear, particularly in those countries with highly developed forest-based industries that high-order expenditure on indigenous forest renewal is no longer an option; predictions are that failure to reforest would be to imperil some state — and even national — economies. Politics being what they are, it is unlikely that this would happen as quickly as most foresters are convinced is necessary. How be it, the consequence surely must be that the cost to their owners of renewing and intensively managing these depleted natural forests, in due course will become as much a component of the price of the wood they produce for export, as it is to those who grow wood in plantations for home consumption.

It seems reasonable to accept, in historical terms at least, that the demand for forest products will remain constant, that there will be pressure to maintain supplies and that
the base price for wood more realistically will reflect the cost of growing it. If we add to these factors the even more important influence of modern forest science and technology, the picture becomes even clearer for the intending investor when calculating the return on investment. It is commonplace today for spectacularly productive fast-growing species in plantations to give profitable final returns well within the working life of the foresters who establish them.

The results of forest research, accelerating over the last few decades, tells us how best to select and, if necessary, amend sites, what management treatments are optimal; the prospect, moreover, is for genetic manipulation of the desirable trees, leading to production figures which can be double present yields on the same sites and with similar treatments.

There is also the option I have mentioned — for the forest owner to become involved in the wood conversion industries: the vagaries of the market (and selling prices) are controlled very substantially when its production is carried some stages further, from wood at the stump into integrated forest products. Instances of this, too well known to need detailing here, have emerged around the world during this century and while some process trees from existing forests, largely they are designed to convert material from man-made forests; they operate with increasing surety and success and provide a range of models for the investor.

All in all, the decision-makers of this era, when planning forestry enterprises, are less blinkered than their predecessors. Nevertheless, it still needs a highly sophisticated sensing system which takes in enough parameters to make a reasonably acceptable 25-year prediction — but, by painstakingly reviewing the experience of the past several decades and extrapolating ahead, it now can be done.

Which Model?

Let me enlarge on some of the more significant points I have made, on the choice of a model or models in the better use of investments. Among these is, that today's forest enterprise differs only in detail from other forms of resource utilisation, whether it be mining and manufacture or agriculture; it should be judged in the same way. This would be to reject the notion that the investment could and should be made, primarily for social reasons, because land happens to be available because:

providers of investment funds who, most often, are elected Government officials with limited terms of office, are able readily to forget the underlying highmindedness of such a project if its continuance drains funds away from other forms of investment which are more palatable in their electorates; and,

on the other hand, if it is pre-planned primarily to yield a surplus on capital employed (and without any special regard for its social implications), usually it finds no difficulty in enlisting continuing support.

Another is that plantation forestry, as it now has evolved, can return more and sooner to be investor than any other contemporary form of production forestry. Accepting this, it would follow that it is here that investor should seek exemplars.

Some factors which have been put forward as important for successful reforestation (Boardman, 1984) are:

adequate investment in research into plantation establishment before large-scale planting commenced;

favourable climatic and ecologic conditions for plantation forestry;
high standards of site preparation, plantation management and maintenance; achievement of significant productivity gains through use of exotic species or by tree improvement; clear definition at the outset of a plantation programme of end-use objectives, including early commitment to construction of utilisation plant; sustained political commitment to policy and to carry through and sustain the programme; the introduction of very short rotation fast-growing species which produce significant income in a quarter of the time usual with traditional rotations.

Foresters, such as those at Victoria in 1985, modestly would admit to being as well informed professionally as those from any other discipline, would not quarrel with any of these as generalities. It would be to strain the point to dwell on past centuries of classic European forest establishment and tending practice or more recent developments in other parts of the northern hemisphere. There is a case however to be made for a closer look at the range of options presented by plantation forestry as it has evolved in the southern hemisphere over the last hundred years.

These options are to be seen best, I believe, in former European colonies, now independent industrialised nation states with well-established infrastructures, but with depleted indigenous forests. Beginning tentatively towards the end of the nineteenth century, reforestation by plantation establishment has been at a steadily increasing pace, hemisphere-wide, and on a disproportionately large scale considering population size and capital availability in these then-developing countries. Unlike the measured tenor of old-world practice, it has been one marked by stops, starts and U-turns in response to evolving experience. Species, generally exotic, had to be found which would grow in plantation formation, in environments often quite unlike their native habitats, as were the tending practices essential for their protection. Moreover, the most productive species yielded wood with wood properties markedly different from that of old-growth trees and which met lukewarm market acceptance from the wood-using industries. Solutions had to be found, initially by trial and error, later by systematic silvicultural and other research, and in the case of utilisation, on wood science and technology.

Judged on profitability and continuing viability, examples are to be seen in countries spread across the southern oceans from Africa, Australia and Oceania and South America.

They demonstrate almost every form of plantation forestry, from wattle bark to saw and plylog and other forms of industrial wood production and in a range of sequential stages of development. Geographically, they are in the warm-temperate zones of the middle latitudes, with longer growing seasons and faster growth rates than northern continental forests: several crops can be produced in a century. Many of these southern enterprises have had to meet and solve an almost infinite range of problems and, perforce, this has been compressed inside a time-span which barely would cover one northern conifer rotation. While conceding that the management of indigenous forests and the establishment of plantations in these regions is grounded solidly on European forest science and silvicultural methods, contemporary practice is shaped by the now encyclopaedic body of knowledge flowing directly from the southern reforestation experience. In all, it embraces just about every form of forestry endeavour and provides any number of models — from solidly successful through to dismal failures.

The experience has been wide and varied; but as has been noted (B. J. Allinson, 1979), too little advantage is taken of the freedom of enquiry which is available: it seems that we foresters share the human failing that we tend to construct the future without
digesting fully the lessons of the past and before mastering the present. Ignoring the
fruits of experience when planning a self-sustaining forestry investment is to put its full
potential at risk.

Narrowing the Focus

Earlier I noted there was value in weighing the options presented by successful forestry
enterprises in southern hemisphere countries. This should not be taken to imply that
these conform to any particular uniform environmental, organisational or operational
pattern. While it is true that they share favourable growth conditions, they are as diverse
as may be found anywhere and this has resulted in the present wide array of economic
and commercial industrial roundwood production and utilisation alternatives — *i.e.*:

The climates, depending on latitude, altitude, location *vis-a-vis* oceanic and
continental air movements, produce disparate conditions for establishing and
managing plantations; wildfire and windthrow are but two examples.

Topography is as varied, markedly influencing tending and harvesting
practices and costs.

Forest soils, derived from differing geological origins, can and do vary from the
most productive to those so infertile as to be suitable only marginally for use
under successive crops.

Demographically, despite cultural and other similarities, there are differences
in population size and composition, and degrees of urbanisation and
industrialisation which pervasively affect the local consumption and exportable
surpluses of forest produce.

The effect of these divergent influences was that, in the pioneering phases of creating
man-made forests in untried circumstances, errors and omissions were inevitable. In
hindsight, it must be acknowledged that the scale of error often was magnified because of
untested assumptions, a meagre data base and the haste (in a forestry context) in which
many planning decisions were made. It is not necessary to enlarge on them here, for they
are amply described in the literature. Rather, it is more rewarding to look to the
principles which embody the lessons of this accumulated experience. Earlier, I referred
to seven such, put forward at a recent Conference, where they were mentioned, *inter
alia*, as ‘some’ important factors. The proceedings of this ‘Symposium on Site and
Productivity of Fast Growing Plantations’, contains 68 invited and voluntary papers
citing over 2,000 literature references, may be accepted as the leading edge of forest
science and technology in this topic.

Other symposia (1979, 1983) cover interrelated aspects and their proceedings,
combined, provide a catalogue of contemporary received wisdom on how best to create
and utilise man-made forests (I note in passing that a majority of the authors have
antipodean backgrounds). The point I am making here is that this sector of the forestry
wheel is alive and well — there is no need to re-invent it. The parameters are there and
all within them is recorded. The data base is wide. It includes the effects, avoidable and
unavoidable, of natural catastrophe and others resulting from human error, less
dramatic perhaps, but often as wasteful of effort in the long term.

The sources are many and varied, based on the experiences of federal, state and
provincial forest authorities, privately and State-owned industrial forestry organisations
with various degrees of integration. Their successes are documented as are their failures,
which still occur (Sutton, 1984). Notwithstanding any such failures, it is well
demonstrated that plantations of fast-growing species will succeed when centuries-old
fundamentals are wedded to the application of other multi-disciplinary sciences and technologies, many of which have developed only during the life-time of most of us alive today. Despite environmental differences which exist, country by country and within countries, it is possible to select a suitable species, from a stable of well-pedigreed candidate species, which will be specially productive within the constraints of a particular environment. However it is to be recognised that, while essential and, no matter how favourable, this factor alone is not enough to ensure the viability of a plantation enterprise. There are many interactions to be allowed for, and I share the view that when planning the chain of inter-related events, it must begin with target estimates of the forest crop's value on the stump, based on the product range and market price of manufactured forest products at the time of conversion. Only then is it possible for the prospective investor to consider, realistically, whether the costs of the other links in the chain can be justified. Among these would be, how and by whom the crop should be harvested and converted, then in reverse progression, its treatment and protection after establishment, the costs of ensuring a superior genetic heritage of the subject species and its provenance coupled to the site and, if necessary, amendment of the site itself. This could seem to be both painfully self-evident to some and over-simplified and hopelessly unqualified to others. The proposition is not a new one to our profession, however, it has been advanced often enough, albeit ruefully, as an ideal and beyond realisation.

Returning to the data now available in the literature and in computer software, the investor can readily assess and choose confidently between the optional benefits and costs of alternative silvicultural regimes. However, if an essential feature of economic modelling using this material has to rely on supply-demand predictions a generation hence, the range of options widens: decisions made in these circumstances have to allow for 'worst-case' market conditions. The evidence now is that over-supply, a recurring feature of the world trade in wood with cyclic peaks and troughs, is evening out, suggesting the world has entered the final phases in the depletion of naturally occurring forests.

We have all heard or read, at some time or other, that the time has come to plant forests to replace them and one (S. B. Elliot, 1913) in particular appeals to me. Written as a manual for 'foresters, students, laymen in forestry, lumbermen, farmers and forest owners who contemplate growing trees for economic purposes', it says:

'. . . tree planting in this country (U.S.A.) will not be engaged in any great extent unless it can be put on a paying basis and become a profitable, self-sustaining enterprise';

and

'logically, the cost of growing trees for lumber should govern present prices, now that virgin forests are nearly extinct, but as the forests of the past cost nothing to produce them, no additional price has been added to the cost of manufacture, other than which has been denominated stumpage and the profit which the manufacturers have been able to secure. The super-abundance of forests has prevented much increase of cost, but when they are gone, the cost of production will assuredly control.'

Seventy years later a contemporary view (Sutton 1984) on the same topic is that (probably early next century) 'the yield and quality of the remaining virgin forest will be so poor, and the exploitation cost so high that the supply demand position at that time will ensure the profitability of fast-growing plantations.'

If this is so, and I am confident that it will be (give or take a decade), forest growers with seedlings in the ground can look forward with some confidence to their harvest.
That confidence will be more than justified if their plantings are planned objectively and in total perspective — with site and seed selection related to final conversion into, and marketing of, forest products.

REFERENCES


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WOODY VINES AND FOREST MANAGEMENT IN MALAYSIA

By F. E. PUTZ*

SUMMARY

In lowland dipterocarp forest in Malaysia, woody vines increase damage associated with felling and slow rates of regeneration after selective logging. When trees connected by vines are felled, they tend to pull each other down. Vines have flexible stems and generally survive falling. The fallen vines sprout profusely and give rise to many of the vines that infest the trees that are supposed to constitute the next timber crop.

Vine cutting prior to logging has advantages over post-felling vine control. If the vine treatment is sufficiently in advance of logging for the stems to decay, logging damage is decreased. Although the rooted stumps of cut vines may sprout, by making sure that vine stems are dead before they fall, a major source of vines in regenerating forest is removed.

RÉSUMÉ

Dans les forêts basses de Diptérocarpacees de la Malaisie les vignes ligneuses accentuent les dégâts liés à l’abattage et la lenteur de la régénération après des coupes selectives. Quand des arbres liés par des vignes sont abattus, ils ont tendance à s’abattre. Les vignes ont des tiges souples et en général survivent à l’abattage. Les vignes tombées à terre produisent beaucoup de pousses et engendrent beaucoup des vignes qui infestent les arbres qui doivent constituer la prochaine culture de bois d’œuvre.

La coupe des vignes avant l’abattage peut être plus profitable que la lutte contre les vignes après abattage. Si le traitement des vignes a lieu assez en avance de l’abattage, afin que les tiges puissent déperir, les dégâts liés à l’abattage sont réduits. Bien que les souches enracinées des vignes coupées puissent pousser, on enlève une source principale de vignes dans les forêts régénérantes en assurant que les tiges des vignes sont mortes avant qu’elles tombent à terre.

RESUMEN

En bosques dipterocarpios de tierras bajas en Malasia, las enredaderas leñosas aumentan el daño asociado con la tala de árboles y una lenta regeneración después de una tala selectiva. Cuando se cortan árboles conectados por enredaderas, tienden a derribarse los unos a los otros. Las enredaderas tienen tallos flexibles y generalmente sobreviven la tala. Las enredaderas caídas germinan profusamente y producen muchas de las enredaderas que infectan los árboles que van a formar la nueva cosecha de madera.

El cortar las enredaderas antes de los árboles, tiene más ventajas que el cortarlas después. Si el tratamiento de la enredadera se lleva a cabo lo bastante antes de la tala para que los tallos se pudran, el daño que sufren las maderas es menor. Aunque los muñones arraigados de las parras pueden germinar, si nos aseguramos de que los tallos están muertos antes de que caigan, nos deshacemos de la mayor fuente de enredaderas en bosques en estado de regeneración.

Assistant Professor, Department of Botany, University of Florida, Gainesville, Florida 32611, U.S.A.

[Ed. The word “vines” is used in its rainforest sense, meaning lianas or woody climbers.]
Introduction

Foresters in both temperate and tropical regions have long been aware that vines can damage trees. The effects range from increasing the susceptibility of trees to ice damage (Siccama et al., 1976) to the suppression of regeneration (e.g. Jones, 1950; Foggie, 1960). Although vines have frequently been mentioned in the literature of forest management, many of the accounts are not quantitative and in some cases contain serious misconceptions about vine biology. It is generally recognised that the proliferation of vines occurs primarily in severely disturbed areas, for example, along skid trails and in large blowdowns (e.g. Wyatt-Smith, 1954; Webb, 1958). As logging becomes less and less selective, tropical foresters are becoming increasingly concerned about vines (Neil, 1984).

In this paper I review studies on the roles of woody vines (also called lianas, bushropes, and climbers; henceforth called vines) in natural and managed dipterocarp forests in Malaysia. Data from both the Peninsula and Sarawak will be discussed and studies conducted elsewhere in the tropics will be mentioned. A descriptive account of the natural history of vines will be followed by a review of studies on the effects of vines on felling damage and regeneration. Finally, silvicultural treatments designed to reduce felling damage and post-felling vine proliferation will be proposed.

The natural history of vines

Nearly one-half of the families of vascular plants contain climbing species (Schenck, 1892). The major vine species containing families in Malaysia are Leguminosae, Annonaceae, and Palmae. There is a tremendous diversity of phylogenetic backgrounds among climbing plants; vines are included among gymnosperms (Gnetaceae), climbing bamboos (Gramineae), climbing pandans (Pandanaceae), and a great variety of dicotyledenous families. This wide range in evolutionary histories precludes making generalisations that apply to all vines. Most of the discussions in this paper best pertain to dicotyledenous vines.

Although vine seedlings are generally self-supporting to a height of 50–100 cm, to reach maturity vines require the mechanical support of other plants. The dimensions of supports (trellises) on which vines can climb depend on the climbing mechanism used and the length of self-supported leader shoots that vines can suspend between adjacent supports. (Woody vines that climb by adhering to tree bark are rare in Malaysian forests for an as yet undetermined reason.) Although vines that can grasp supports as much as 30 cm in diameter are known (Putz and Chair, 1983), most vines are restricted to growing on trellises made up of structures less than 10–15 cm in diameter. These support structures need to be separated by less than 1.0–1.5 m in order for most vines to grow from one support to the next. Canopy trees in tall forest are at least 20 cm dbh and thus their crowns are accessible only to vines that have ascended a series of successively taller supports. If a canopy tree already has vines, however, its crown is easily invaded by other vines that climb up the stems of earlier colonizers. The process of vines growing up other vines gives rise to many of the "climber towers" often observed in logged areas.

Vine stems are generally small in diameter but supply large leaf masses with water and nutrients (Putz, 1983). Little is known about the root systems of tropical vines, but xylem transport has been the subject of several investigations (e.g. Scholander et al., 1957, 1961). Vine stems are extremely efficient conduits because they contain large diameter vessels; flow rates in vines increase with the fourth power of vessel radius (Zimmerman, 1983). High flow rates coupled with xylem vessels that remain functional for many years...
WOODY VINES IN MALAYSIA

(Putz, 1983) allow vine stems to be slender and yet conduct sufficient water and nutrients to supply large masses of leaves.

The stems of vines are extremely flexible. This is due both to their length:diameter ratios and to their internal structures. Vines are characterised by their anomalous secondary growth (e.g. Obaton, 1960). In fact, "normal" wood growth is unusual among vines. Most vine stems contain large quantities of thin walled cells interspersed among the xylem vessels and fibre bundles. The soft tissues include intruded phloem, included phloem, and masses of parenchyma cells. The isolation of bands of fibrous tissues in a soft matrix reduces the likelihood of mechanical failure when a stem is bent and limits crack propagation when failure does occur. When a vine-laden tree falls, most of the vines it was carrying do not break but rather root and sprout new shoots along the fallen stems. The abundant shoots produced along the stems of fallen vines are a major cause of the vine tangles encountered in natural treefalls and in logged areas.

Factors influencing the abundance of vines

The abundance of vines in mature tropical forests seems to vary both with the frequency and severity of disturbance and with soil fertility. The importance of disturbance in the proliferation of vines will hopefully become apparent in the discussion of logging damage that follows. The positive correlation between vine abundance and soil fertility is less well understood. The relationship has, however, been observed by researchers in various parts of the tropics including Sarawak (Janzen, 1974; Proctor et al. 1983; Putz and Chai 1983), Venezuela (Putz, 1983), Guayana (Davis and Richards, 1934), and Costa Rica (Holdridge et al., 1971).

Changes in forest structure associated with logging activities allow the proliferation of vines. Vines germinating from seeds, especially herbaceous vines, are common on the bare mineral soil exposed along extraction roads (Neil, 1984). The vine tangles that often develop in these severely degraded sites can interfere with tree regeneration for many years. Elsewhere in logged forests the abundance of vines is correlated with logging intensity.

Vine-related effects of post-felling management systems applied to selectively logged dipterocarp forests were compared by Putz et al. (1985). The treatments applied were a modified "Malayan Uniform System" (Wyatt-Smith, 1963) and "Liberation Thinning", both applied at several different intensities (for details of treatments see Hutchinson, 1982). The plots were established by a joint project between the Forest Department of Sarawak and the Food and Agriculture Organisation of the United Nations. The treatments were compared on the basis of the proportions of the trees remaining after logging and poison girdling that were vine infested. In addition to the prescribed poison girdling of all but the selected (reserved) trees (Malayan Uniform System) or poison girdling only those trees interfering with the growth of the reserved (selected) trees (Liberation Thinning), all vines were cut in the treatment plots but not in the control plots. Four or five years after treatment (six years after logging) the plots were recensused and the proportion of vine-infested trees was recorded.

Among the treated plots the proportion of trees with vines increased with the intensity of the treatments. In following the Malayan Uniform System, more trees were poison girdled and consequently more of the canopy was opened than was the case with Liberation Thinning. Generally, more trees were vine infested in the plots treated with the Malayan Uniform System than in the Liberation Thinning plots (Putz et al., 1985). Vine infestations in the control plots (no vine cuttings) were generally higher than in the
plots treated with Liberation Thinning. Even with the cutting of all vines after logging, however, more trees were vine-infested in several plots treated according to the Malayan Uniform System guidelines than in the control plots in which the vines were not cut.

A disturbingly strong trend in all of the plots was for trees of commercially desirable species to suffer heavier vine infestations than pioneer (light demanding or weedy) tree species like *Macaranga* spp., *Mallopus* spp., and *Glochidion hypoleucum*. The proportion of vine infested trees averaged over all 22 plots was 49.0 for the commercially valuable species (s.d. = 11.9) and 25.7 for the pioneer trees (s.d. = 13.5) (Putz *et al.*, 1985). Pioneer trees may avoid the depredations of vines by growing rapidly and self-pruning lower branches, hence reducing their trellis-like qualities. Furthermore, *Macaranga* spp. trees are symbiotically associated with ants that are known to remove some insect herbivores (Tho, 1978) and also remove the tendrils of vines that grasp their host (Putz *et al.*, 1985). Because they can avoid or shed vines and thus surmount vine tangles, pioneer trees may reduce the vigour of light demanding vines along extraction roads and in other severely disturbed sites.

**Felling damage attributable to vines**

When vine-laden trees are blown or cut down, they cause more damage to neighbouring trees than do vine-free trees of the same size. In mature lowland forest on Barro Colorado Island, Panama, Putz (1984) found that the number of trees knocked or pulled down when trees fell was correlated with the total basal area of vines carried by the major canopy gap making tree. This effect was more clearly demonstrated in experimental studies conducted by Fox (1968) in Sabah and by Appanah and Putz (1985) in Peninsular Malaysia.

Fox (1968) experimentally tested the hypothesis that trees with vines do more damage to other trees when they fall than do vine-free trees. In a forest in Sabah with an average of 56 vines 2 inches dbh per acre (138/ha 5.1 cm), Fox cut all vines in five randomly selected plots and left the vines in adjacent plots alone. All trees of commercially acceptable species 12–72 inches in girth (approximately 10–58 cm dbh) were measured and numbered in all the plots. Seven months after the vines were cut, the area was logged and damage to the intermediate size trees was assessed. The amount of timber extracted from each plot was recorded but not controlled. The amount of bark and crown damage was similar in the control and treated plots. There was, however, a strong effect of vine cutting on overall damage insofar as more trees were snapped off or uprooted in the control plots than in the treated plots (62 vs. 44%, respectively). The author pointed out that the results of this experiment were confounded to some extent by spatial variation in the intensity of logging.

In another experimental investigation of felling damage attributable to vines, Appanah and Putz (1985) cut the vines on 25 commercial size timber trees (40 cm dbh) nine months before felling. Another 25 vine-infested trees served as controls. The felling of vine-laden trees caused the uprooting or trunk snapping of an average of 7.2 neighbouring trees (s.d. = 4.1) while trees with cut vines only pulled or knocked down an average of 4.0 neighbouring trees (s.d. = 3.5). After removing the effect of a slight difference in the sizes of the felled trees by analysis of covariance, the difference was found to be statistically significant (P<0.01). There was no apparent effect of vine-cutting on bark or crown damage, but crown damage is difficult to assess.
Effects of vines on tree growth

The growth rates of trees of all sizes seems to be adversely effected by the presence of vines. This is not surprising considering that most canopy vines display their leaves above the leaves of their host trees. This was clearly shown in a study of tree leaf areas in Thailand by Ogawa et al. (1965). They found that vine-laden trees have less foliage than vine-free trees and that the observed decreases in tree leaf area approximately equalled the amount of vine foliage supported by the trees.

Most of the evidence for the negative effect of vines on tree growth rates is, however, correlative. Lowe and Walker (1977) included a vine infestation variable (a four point scale) in their study of factors affecting the growth of Khaya ivorensis and Sterculia rhinopetala in Nigeria. They found a significant (P<0.05) negative correlation between the total basal area of vines carried by the trees and their basal area increments over a 10 year period.

To ground-dwelling foresters, the effects of vines on tree growth are most apparent in forest regenerating after logging. The importance of controlling vines on young trees has been stressed repeatedly (e.g. Dawkins, 1958; Wyatt-Smith, 1963; Nicholson, 1965). In a quantitative study in forest regenerating after commercial logging in Sarawak, Putz et al. (1985) compared the growth rates of vine-free and vine-infested trees of commercially acceptable species. They found that trees with vines grew more slowly than vine-free trees. By using data on tree growth and vine infestations from sequential plot censuses, they suggested that vine-free trees that grow rapidly are more likely to remain vine-free than are slower growing trees.

In addition to slowing the growth of their host trees, vines often cause the deformation of the boles of their host trees. In Sarawak, Putz et al. (1985) found that stem deformities were more common among vine-infested trees than among vine-free trees. The causative nature of this relationship seems obvious but should be tested experimentally so as to eliminate the possibility that deformed trees are inherently more susceptible to vines.

G. Stevens (in preparation) investigated the effect of vines on fruit production by Bursera simaruba trees in Costa Rica. He removed the vines from five reproductively mature trees and used five vine-infested trees as a control. Fruit production was determined by counting the fruits on each of the trees. Trees from which the vines were removed produced more fruits than the vine-infested trees.

Methods for controlling vines

Vines have been controlled by grazing, fires, herbicides, and planting cover crops but most frequently their stems are cut. The appropriate control method will vary with site conditions and the severity of the vine problem. Regardless of the technique chosen, there remains the fundamental question of when to treat vines, before or after logging.

Cutting vine stems before logging can reduce both felling damage and the abundance of vines in forest regenerating after the harvest. Vine stems cut near the ground usually sprout from the rooted end but hanging portions generally die and rot within a few months. This is not the case, however, with strangler figs (Ficus spp.) and other hemiepiphytes; these plants respond to cutting by sending down new roots from above the cut. If vine cutting has occurred sufficiently in advance of logging for the stems to weaken, damage to intermediate size trees during logging is reduced. Another advantage of pre-felling vine cutting derives from the flexibility of vine stems and the tendency for fallen stems to sprout profusely along their entire recumbent length.
Many of the vines that create such a nuisance after logging are sprouts from vines that fell to the ground during logging. By sorting through vine tangles several years after logging, Appanah and Putz (1985) found that half of the vine stems not cut prior to logging survived the felling of their host trees. Furthermore, they found that more than half of the vines on infested trees were sprouts from fallen vines. Fallen vines also gave rise to a high proportion of the vines in natural treefalls in Panama (Putz, 1984) and in logged and silviculturally treated forests in Sarawak (Putz et al., 1985).

Although pre-felling vine cutting is often the prescribed treatment, vines can be such an obvious problem in logged forests that post-felling treatments are required. In some areas, access to the forest is easier after logging than it is 6–9 months before logging when roads may not yet have been constructed. In my opinion this is the only advantage of trying to cut vines after logging. Vines seem much more numerous after logging and grow down near the ground where they interfere with the passage of work crews through the forest. Additionally, it is very difficult to kill the prostrate stems of fallen vines from which sprout so many of the vines that menace young tree crops. In contrast, cutting upright vine stems is quite easy.

Conclusion

Vines increase felling damage and slow tree growth rates after logging but the decision of whether or not to cut vines depends on other ecological and economic considerations. Vines are an integral part of tropical rain forest communities. They provide food and inter-crown pathways for animals that will suffer if vines are removed. In areas cleared down to bare soil, quickly proliferating vines help to stabilise the soil surface and reduce erosion. The decrease in logging damage, decrease in the proportion of deformed trees, and increase in tree growth rates that may result from pre-felling vine cutting may not be economically valuable enough to warrant vine treatment. Cost-benefit analyses under local conditions should be conducted before vine treatments are prescribed.

Acknowledgements

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MULTIVARIATE ANALYSIS OF DATA FROM INTERNATIONAL PROVENANCE TRIALS OF PINUS OOCARPA/PINUS PATULA SUB-SPECIES TECUNUMANII

By J. S. BIRKS and R. D. BARNES

SUMMARY

Multivariate analysis of variance was used to investigate differences in production traits between sub-sets of up to 26 provenances in the international provenance trials of Pinus oocarpa Schiede in 10 localities. Results presented here indicated that there are two distinct groups, one containing four silviculturally superior provenances, Cameliias, Rafael, Mountain Pine Ridge and Yucul, and the other containing typical P. oocarpa. Huehuetenango occupied a unique position. These results supported the recent reclassification of the four provenances into a new taxon, P. patula Schiede and Deppe ssp. tecunumanii (Eguiluz and Perry) Styles, and suggested the possibility of further taxonomic division. It also highlighted both the importance of sampling a species at the edges of its distribution and the value of taxonomic studies in identifying practically useful variation in the natural population. Multivariate analysis might be used to identify natural groupings of provenances on which to base sub-populations for breeding purposes.

RESUME

Dans les tests internationaux de provenances de Pinus oocarpa Schiede dans 10 sites, on a étudié les différences de traits de production entre des sous-ensembles de jusqu’à 26 provenances par analyse multidimensionnelle de variance. Les résultats présentés ici indiquent qu’il existe deux groupes distincts, l’un comprenant quatre provenances supérieures du point de vue de la sylviculture (Cameliias, Rafael, Mountain Pine Ridge et Yucul) et l’autre comprenant des provenances typiques de P. oocarpa. Huehuetenango occupait une position unique. Ces résultats corroboraient la reclassification récente des quatre provenances supérieures dans un nouveau taxon, P. patula Schiede et Deppe ssp. tecunumanii (Éguiluz et Perry) Styles, et proposaient la possibilité de davantage de division taxonomique et soulignaient l’importance d’échantillonner une essence aux limites de sa distribution et la valeur des études taxonomiques pour l’identification dans la population naturelle de variation qui serait utile dans la pratique. On pourrait utiliser l’analyse multidimensionnelle pour identifier des groupements naturels de provenances qui servirait comme base pour des sous-populations pour l’amélioration génétique.

RESUMEN

Se utilizó análisis multivariable de varianza para investigar diferencias en características de producción entre juegos parciales de hasta 26 procedencias en los ensayos internacionales de procedencias de Pinus oocarpa Schiede en 10 localidades. Los resultados presentados aquí indican que hay dos grupos distintos, uno con cuatro procedencias superiores en el sentido silvicultural (Cameliias, Rafael, Mountain Pine Ridge y Yucul) y otro con las procedencias típicas de P. oocarpa. Huehuetenango ocupó una posición única. Estos resultados apoyan la reclasificación reciente de las cuatro procedencias superiores en una nueva taxa, P. patula Schiede & Deppe ssp. tecunumanii (Eguiluz & Perry) Styles y sugieren la posibilidad de más divisiones taxonómicas. Además destaco la importancia del muestreo de una especie en los
márgenes de su distribución natural, y el valor de estudios taxonomicos en la identificación de variación de utilidad práctica en la población natural. El análisis multivariable podría ser utilizado para identificar agrupamientos naturales de procedencias, en los cuales se pueden basar sub-poblaciones para fines de mejoramiento.

Introduction
The Commonwealth Forestry Institute\(^1\) started exploration and seed collection in natural stands of *Pinus caribaea* Morelet in Central America in 1963. The research programme was soon extended to include *P. oocarpa* Schiede which replaces *P. caribaea* at higher altitudes on less fertile and drier sites. Seed was collected from the whole distribution of *P. oocarpa* in order to sample the full range of variation and herbarium specimens were taken with every seed collection for taxonomic study. Seed was distributed to more than 60 countries and experimental trials were planted from 1972 onwards.

A subset of trials was chosen for intensive assessment coordinated by the CFI in 1978 (Barnes, Gibson and Bardey, 1983). It was evident from the data that, in most trials, four provenances, Camelas, Rafael, Mountain Pine Ridge and Yucul, performed much better for a range of characteristics than all the others. Styles (Barnes and Styles, 1983) believed that these four provenances were taxonomically more like *P. patula* Schiede and Deppe. He placed them in a new taxon, *P. patula* ssp. *tecunumanii* (Eguiluz and Perry) Styles which he considered to be a southerly extension of *P. patula* (Styles, 1985) and synonymous with *P. tecunumanii* Schwerdtfeger. Some taxonomists still hold that the latter should be a species in its own right (Eguiluz and Perry, 1983).

The superior growth of the four provenances in the trials prompted an intensive programme of re-exploration of the natural stands. Despite the clear differences exhibited by young trees in the exotic environments, there continued to be problems in distinguishing *P. patula* ssp. *tecunumanii* from *P. oocarpa* as many taxonomic characteristics were extremely variable.

In a recent numerical study, McCarter and Birks (1985) investigated ten populations from the areas of the original *P. oocarpa* collections. A multivariate analysis of fifteen needle and cone characteristics showed there to be taxonomically two distinct groups. The least variable was typical *P. oocarpa*, the other was what Styles considered to be *P. patula* ssp. *tecunumanii*. This previous study has four provenances in common with the *P. oocarpa* provenance trials examined here, Zamorano and Lagunilla classified as typical, and Yucul and Rafael, classified as *P. patula* ssp. *tecunumanii*.

The Provenance Trials and the Method of Analysis
For the analysis presented here, ten trials (Table 1) were chosen from those included in the intensive assessment programme. A subset of between six and twenty provenances out of a total of 26 provenances were planted in each trial. The experimental design was a randomised complete block with three, four or five blocks and, usually, 49-tree square plots, but this varied according to local practice. The intensive assessment was carried out at approximately six years of age when a large number of traits was measured (Barnes, Gibson and Bardey, 1983). Univariate analyses have been performed (Barnes, Gibson, and Birks, in preparation). The work presented here is the first multivariate analysis of this data.

\(^1\) The Oxford Forestry Institute from 1st October 1985
MULTIVARIATE ANALYSIS OF PINE DATA

Figure 1. Map of Central America.

Table 1
Details of locality and age for ten Pinus oocarpa provenance trials

<table>
<thead>
<tr>
<th>Provenance trial site</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Altitude metres</th>
<th>Age years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia, Melville Island</td>
<td>11°25'S</td>
<td>130°00'E</td>
<td>49</td>
<td>5.9</td>
</tr>
<tr>
<td>Brazil, Agudos</td>
<td>22°22'S</td>
<td>48°52'W</td>
<td>550</td>
<td>6.3</td>
</tr>
<tr>
<td>Ecuador, Conocoto</td>
<td>0°16'S</td>
<td>78°25'W</td>
<td>2500</td>
<td>6.2</td>
</tr>
<tr>
<td>Kenya, Turbo</td>
<td>0°38'N</td>
<td>35°41'E</td>
<td>1700</td>
<td>7.6</td>
</tr>
<tr>
<td>Puerto Rico, Anasco</td>
<td>18°20'N</td>
<td>67°07'W</td>
<td>150–200</td>
<td>5.7</td>
</tr>
<tr>
<td>R.S.A., Transvaal, Wilgeboom</td>
<td>24°58'S</td>
<td>30°58'E</td>
<td>945</td>
<td>7.5</td>
</tr>
<tr>
<td>R.S.A., Natal, KwaMbonambi</td>
<td>28°45'S</td>
<td>32°00'E</td>
<td>65</td>
<td>7.2</td>
</tr>
<tr>
<td>Thailand, Huey Bong</td>
<td>18°12'N</td>
<td>98°25'E</td>
<td>790</td>
<td>6.5</td>
</tr>
<tr>
<td>Thailand, Chumporn</td>
<td>10°52'N</td>
<td>99°15'E</td>
<td>70</td>
<td>6.5</td>
</tr>
<tr>
<td>Zambia, Ndola East</td>
<td>13°00'S</td>
<td>29°00'E</td>
<td>1300</td>
<td>6.1</td>
</tr>
</tbody>
</table>
Table 2

Descriptions for ten variables assessed in the *Pinus oocarpa* provenance trials.

- Height
- Diameter measured at breast height
- Bark thickness measured at breast height
- Stem straightness
- Total number of whorls of branches between 1 and 6 metres above ground
- Longest internode length
- Degree of kinking of branches and leading shoots
- Average number of branches per whorl
- Percentage of trees in a plot that are forked
- Percentage of trees in a plot bearing cones

Ten variables (Table 2) were chosen for a multivariate analysis. The multivariate analysis of variance table is:

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SSPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provenances</td>
<td>h</td>
<td>H</td>
</tr>
<tr>
<td>Blocks</td>
<td>b</td>
<td>B</td>
</tr>
<tr>
<td>Residual</td>
<td>r</td>
<td>R</td>
</tr>
<tr>
<td>Total</td>
<td>t</td>
<td>T</td>
</tr>
</tbody>
</table>

**H, B, R** and **T** are sums of squares and products matrices (p x p) for a p-variate multivariate analysis of variance. The expected response vectors of the provenances ($\mathbf{m}_i, i = 1, h + 1$) are the coordinates of points in a p-dimensional space in which each of the p axes represents one of the original variables. The null hypothesis is that the expected response vectors of the provenances are equal, i.e.:

$$\mathbf{m}_1 = \mathbf{m}_2 \ldots = \mathbf{m}_{h+1}$$

To test the null hypothesis, the ratio of the determinants of the matrices **H** and **R** is used to calculate a statistic (Wilks' $\Lambda$ statistic) with which to test for differences between provenances. This is analogous to the variance ratio F-test in the univariate analysis of variance. Univariate analyses of variance of two or more traits may show significant differences either independently (e.g. height and stem form) or dependently because of correlations between the variables (e.g. height and diameter). The multivariate analysis of variance provides an overall test for the provenance differences and the probability level is higher when the separate variables provide new information than when they are giving repeated information due to such intercorrelation.

Canonical analysis uses the **H** and **R** matrices to calculate new axes which are linear compounds of the original variables. The separation of the $\mathbf{m}_i$'s projected onto the first new axis, the first canonical variable, is a maximum, and successive canonical variables are calculated which show decreasing separations of the projections of the $\mathbf{m}_i$'s. All pairs of canonical variables are not correlated. Interest centres on the first and second canonical variables which show the greatest separation in two dimensions of the provenance expected values when plotted against each other.
Figure 2. Plot of canonical variables showing the mean values for each provenance of the *P. oocarpa* trial at Wilgeboom, Transvaal, South Africa. The standard error of a difference between two provenance means is .09 for either canonical variable.

Figure 3. Plot of canonical variables showing the mean values of the *P. oocarpa* trial at Conocoto, Ecuador. The standard error of a difference between two provenance means is .12 for either canonical variable.
Figure 4. Plot of canonical variables showing the mean values of the *P. oocarpa* trial at Ndola East, Zambia. The standard error of a difference between two provenance means is .24 for either canonical variable.

Figure 5. Plot of canonical variables showing the mean values of the *P. oocarpa* trial at Agudos, Brazil. The standard error of a difference between two provenance means is .11 for either canonical variable.
Results
The multivariate analysis of variance showed significant differences between provenances at all sites. Of greater interest is the classification of the provenances into groups using the results of the canonical analysis. Figures 2–5 show the provenance mean values of the first canonical variable plotted against the second for a sample of four *P. oocarpa* provenance trials chosen as representative of the ten trials. A pattern emerges across all trials. Rafael, Yucul and Camelas are in a separate group from the *P. oocarpa* provenances typified by Lagunilla and Zamorano. Mountain Pine Ridge is apart from this group and the *P. oocarpa* group but closer to Rafael, Yucul and Camelas. Huehuetenango is unique amongst this set of provenances.

Discussion and Conclusions
The analysis has clearly indicated that the four provenances which had outstanding performance in the trials, Rafael, Yucul, Camelas and Mountain Pine Ridge, are distinct from the main body of *P. oocarpa* provenances and this reinforces their classification as a separate taxon. Huehuetenango is the most north-westerly provenance and closest to Mexico. Mexican sources of *P. oocarpa* are quite different from Central American sources when grown as exotics; most conspicuously, they have very poor stem form. Perhaps there is a case for their taxonomic separation.

The purpose of provenance trials is to establish, for breeding purposes, those provenances which perform best in given environments. When univariate analyses are calculated for each variable, conflicting results are often obtained and it is difficult to make clear decisions in selection. One method of resolving this is to construct indices from several variables. This has the disadvantage that it is not easy to make a rational and informed choice of the weightings of individual variables in the indices. The plot of the canonical variables calculated from a multivariate analysis of variance shows groups of provenances which have very similar performances for a number of characteristics within an environment. These may form natural groups on which to base breeding populations.

The five populations that are individually distinct from the main body of *P. oocarpa* provenances occur on the edges of this closed-cone pine complex in Central America, and this supports the view of Namkoong (1984) that it is particularly important to sample species margins to capture any locally concentrated alleles.

Of great interest is the fact that the results of the multivariate analysis of variance of these production traits closely follow the results of the taxonomic study of the same material (McCarter and Birks, 1985). The two multivariate analyses, one based on a set of taxonomic characteristics and the other based on a set of production variables, independently grouped the provenances in the same way. This highlights the value of taxonomic work in the natural stands in identifying variation that has practical value.

Acknowledgements
This work would not have been possible without the co-operation and assistance of the forest authorities in the Central American countries and Mexico where *P. oocarpa* and *P. patula* ssp. *tecumumanii* are indigenous and of the forest authorities and private companies in countries where the provenance trials were planted. The authors and the OFI wish to express their thanks to the many colleagues who helped at all stages of the programme. The Overseas Development Administration of the British Government has been a principal contributor of funds for seed collection and distribution and trial assessment. G. L. Gibson of the OFI carried out the field assessment of the trials.
REFERENCES


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INTEGRATED WOOD-USE CENTRES FOR SMALL INDUSTRY DEVELOPMENT

By R. A. PLUMPTRE*

SUMMARY

Small wood-using industries play a very important part in the economics and development of many tropical countries but often little effort has been put into research for their benefit.

Suggestions are made for establishing integrated wood-use centres for small industry development, to research small scale wood use, introduce new technologies and encourage the influx of skilled personnel for short periods from other countries to stimulate thought, research and the application of new technology.

INTRODUCTION

Foresters frequently tend to undervalue the importance of their industry and its contribution to both employment and economic wellbeing: often this is because of their preoccupation with growing the trees and a lack of reliable statistics showing the very widespread influence of wood and other forest products in the economy of most countries.

Hair (1963), in a study of the role played by wood in the United States economy, calculated that the wood industries accounted for 5.6% of GNP and 5% of employment. Only 4% of the 5.6% was attributable to forest management (all forestry operations.

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including research, to achieve mature standing timber); the other 96% was derived from harvesting and forest industries while only 3% of the employment in forestry and forest industries was in forest management as opposed to 97% in harvesting and industries. The vast majority of the benefit, therefore, is in harvesting and forest industries but forest management is the vital first stage without which the industries cannot operate.

A recent study conducted for FAO (FAO 1985) demonstrates the very important part played in the economies of tropical countries by small wood-based industries and points out that the people employed by these industries are mostly the landless and, therefore, potentially the poorest. In Jamaica, Honduras, Egypt, Sierra Leone and Bangladesh an average of 22% of small industry employment was attributable to small forest-based industries.

Large industries require a large, uniform and, preferably, concentrated forest resource to operate efficiently. The requirement is for an adequate supply of a uniform raw material to produce as uniform a product as possible. Dispersion and variability in the raw material are disadvantages.

Small industries by contrast can cope with, and thrive on, the dispersion and variability of raw material which is common in the tropics particularly where forests have been depleted and trees are in short supply. The present trend is towards fragmentation and disappearance of Government and other large forests near population centres and increasing distances between the population and large blocks of forest.

**Efficiency of Use of the Resource and Size of Industry**

It is sometimes assumed that large industries are more efficient than small ones. Judged in terms of unit cost or quality of a product, they frequently are, but judged in terms of the completeness of utilisation of a limited resource or in terms of provision of numbers of jobs in interesting and satisfying employment they are often far less efficient than small industries. The thousands of small carpenters and craftsmen using wood in India and Bangladesh, for instance, are extremely efficient in their use of a short supply of sawn-wood while sawdust and off-cuts from mills are used by many more thousands as fuel for cooking. By contrast, in some areas of these countries the logging industry and the larger wood-using corporations tend to be wasteful in their use of the raw material particularly in allowing the less durable logs to deteriorate before they reach the primary industries.

In Britain, which imports 90% of its forest products, there are about one million hectares of hedgerows and small farm woodlands which are largely neglected and unproductive of anything much except limited quantities of firewood; these areas could produce large quantities of useful saw, or possibly, veneer logs if they were properly managed and utilised using equipment suitable for processing trees dispersed around farmland. The problem, therefore, is by no means confined to the tropics or the developing world; Britain can, however, still afford to import, whereas many tropical countries cannot: Britain is also currently building up, rather than depleting, its forest resources and small scale machinery is becoming available which can utilise farm-grown trees and be operated by farmers or small contractors.

**Forest Products Research for Small Industries**

The properties of wood and its potential as a raw material for different industries have been researched for a long time and to a high level of sophistication in much of the developed world. Similar research, although on a small scale, has been carried out in the
tropics; usually, however, the research has been directed more towards the larger industries and less towards the smaller, more widespread wood-using industries.

There is a need in tropical countries with a dwindling forest resource to utilise what is left as efficiently as possible and at the same time to demonstrate to local people its value to them and the need to regenerate it.

At present, even where the resource is scarce, it is often under-utilised or misused because the wrong or inadequate technology is used to exploit it or because of a lack of knowledge of the existence of suitable technology.

Because research and promotion have been directed, in the past, towards the larger industries the small industries have received little support and often very little interest or recognition from Government Forest Services or Departments of Industry. Often the best forest has been given to the large industries to harvest and the small industries have had to make do with inferior trees grown outside forest reserves. The best species even on land outside forest reserves are often reserved and can only be felled after royalty payment to a forest service which has rendered very little service to the small forest industries.

There is now a changing attitude to the value of, and need for “social forestry” and this has resulted in some quite encouragingly successful schemes where large numbers of rural people have participated in tree planting.

As yet, however, little recognition has been given to the needs for forest products research directed towards the small forest industries which usually provide more employment and added value than the large industries in developing countries. Research of this nature, if directed towards the real current needs of the majority of the population and seen by them to be assisting them, should result in a better appreciation by the people of the real value of the forest to them and greater determination on their part to see that it is protected and regenerated.

The integrated wood-use centre concept

There would seem, therefore, to be a need for centres for research, demonstration and promotion of technologies which contribute to a better, more integrated, use of the raw material, which are economical in its use and give the highest possible value of useful products.

A centre of this nature would look at the whole range of small scale wood uses in a country, their integration with each other, their efficiency of use of the raw material and their contributions to employment and the economy in general. It would have the functions of introducing new technology from outside the country, researching new technology within it and encouraging the influx of knowledge and skilled personnel to do relevant short term research and extension work.

Appendix 1 gives a list of possible activities for a centre of this nature.

The main activities can be summarised as:

1. Determination of the size, nature and composition of the raw material resource for small industries.
2. Determination of existing consumption of wood products in both small and large industries.
3. Evaluation of existing technology and techniques in small industries and patterns of wood use.
4. Deciding on the need for introductions of existing technology from outside the country.
5. Selection of research needs within the country and the need for collaboration with external agencies to develop new technology.
6. Testing of introduced technology and of new technology developed within the country.
7. Promotion of promising technology to the point where it is commonly used.
8. General aid and advice to small industry, both technical and managerial.

Proposed methods of establishment of wood-use centres

The range of skills required in a centre of this type is probably nearly as wide and demanding as the skills required in a fully fledged forest products laboratory serving the larger forest industries. Few, if any, countries can produce the whole range of skills required.

At the same time it is impracticable and undesirable to set up a large organisation of the size of a conventional forest products laboratory which the country could not afford or operate and which would tend to become “ossified” and underutilised as some tropical forest products laboratories have become in the past.

The following are tentative suggestions for the staffing, equipment and organisation of such a centre:

1. **Staffing**
   A small, balanced team of well trained and imaginative permanent staff should be the aim and might have the following composition:
   - **Head**: A forester or forest industries person with a wide range of experience in small industries, wood properties and utilisation.
   - **Engineer**: An engineer with a broad background of practical engineering, if possible in wood industries, equipped with a workshop and staff capable of building tools and machinery of moderate complexity.
   - **Economist/Industries promotion person**: with experience of small industry development and promotion.

   The three senior staff need backing up by the following technical staff:
   - 3–4 good carpenters/cabinet makers for wood workshop.
   - 3–4 skilled operators for engineering workshop.
   - 1 good saw doctor.
   - 2–4 technicians capable of operating seasoning preservation equipment and carrying out surveys of consumption and resource availability in co-operation with Forest Department staff.
   - 1 technician in charge of wood collection, wood identification and physical and mechanical testing of wood.
   - 2–3 clerical staff.

2. **Equipment**
   The following basic equipment is desirable:
   - Small experimental sawmill capable of cutting most log sizes available and limited logging equipment.
   - Woodworking workshops for research and general construction in wood.
   - Small laboratory for timber identification and testing.
   - Simple but well equipped engineering workshop.
   - Small office block with a good demonstration and publicity room in addition to normal offices.
3. **Transport**

Adequate transport is needed to enable staff to get around the country and make contact with people, to carry out surveys and keep in touch with the real needs of people for developments in better wood use.

Adequate funds would also be needed for overseas travel on study tours to widen the experience of staff and meet workers in other countries doing relevant research and development work.

Much of the infrastructure suggested above is already available at many Forest Department Utilisation sections. The main additions required would be in the quality and standing of the senior staff and in the engineering workshop and associated staff.

**Methods of operation of centres**

The aim should be to develop slowly, starting with a preliminary survey of major needs and the selection of priority areas requiring work to be done. It is clear that only a small proportion of the possible work suggested in Appendix 1 can be attempted at first but flexibility should be maintained by the introduction of technologies and skills from outside the country on relatively short term projects attached to the centre. In this way skills and technology could be drawn on from such organisations as ITDG, TDRI, OFI, universities and colleges, LRD, BRE, TRADA and private firms in Britain or similar organisations in other countries for the period during which they were needed without any long term commitment by these organisations, or by funding agencies.

Initially it might be necessary for one or all of the three key staff to be expatriates while training counterpart staff, but there would only be three of them: it is vital that the quality of staff, both expatriate and counterpart, should be very high. They must be able to hold their own in international as well as local circles if a centre of this nature is to be really effective and capable of attracting inputs from abroad.

**REFERENCES**

FAO (1985). The Contribution of Small-Scale Forest-based processing Enterprises to rural non-farm employment and income in selected developing countries. *FO: Misc/85/4.83p*


*ITDG*  = Intermediate Technology Development Group Ltd  
*TDRI*  = Tropical Development & Research Institute  
*OFI*  = Oxford Forestry Institute  
*LRD*  = Land Resources Division  
*BRE*  = Building Research Establishment  
*TRADA*  = Timber Research & Development Association
Suggested activities for an integrated wood-use centre

Wood Fuel
Survey of woods used for fuel and preferred species, sizes, and properties.
Survey of methods of collection, time spent in collection, quantities used, methods of drying, and m.c. of fuel used.
Survey of existing methods of cooking and stoves used.
Survey of use of charcoal and methods of making it.
Trials of new stoves and designs and methods of making them locally.
Experiments with lopping or thinning as opposed to clear felling of fuel trees.
Research into methods of making charcoal and possibly also collecting tars and creosote for wood preservation.

Poles
Survey of species used, sizes and quantity used.
Survey of building methods and methods of use of poles and posts.
Survey of current methods of preservation, if any.
Experiments with cheap preservatives, particularly those which can be made locally and methods of applying them.

Sawnwood
Survey of methods of production or acquisition of sawn timber and costs.
Survey of quantities, species and sizes of sawnwood used and purposes for which it is used.
Saws, saw designs, methods of using them and the economics of operating them.
Different designs are required for different sizes of log and, in particular, improved human or machine powered saws are required to upgrade the pitsaw.
Survey of methods of seasoning sawnwood, its handling and any defects resulting from mistreatment.
Survey of preservation methods and deterioration in use.
Development of simple air or solar drying methods.
Development of simple preservatives and methods of applying them.

Furniture and Joinery
Survey of species, quantities, sizes and sources of timber used for furniture and joinery.
Survey of designs and methods of construction and sources of supply.
Survey of deterioration, length of life and general performance of joinery and furniture.
Introduction of new tools and machinery of simple design and low cost.
Introduction of better methods of using and maintaining existing tools and machinery.
Introduction of new designs using less material to get the same service.
Introduction of methods of preservation and finishing to increase length of life and appearance.

Wood Crafts
Survey of existing crafts and methods of manufacture.
Survey of possible wood raw material for craft work.
Introduction of new designs and methods of manufacture.
Tools and Tool handles
Survey of wood used in tools and tool handles (species used, seasoning, manufacture and quantities used).
Introduction of new designs and improved methods of manufacture.

Wood in Housing
Survey of building techniques and methods.
Survey of quantity of wood used in different forms in a range of different houses.
Survey of length of house life and how they deteriorate.
Introduction, for trial, of improved methods of building.
Introduction, for trial, of improved methods of wood, thatch and wattle preservation.
Introduction of possible new construction materials and techniques.

Power Generation from wood
Survey of the possibility of using power generated from wood, possibly through gasification; generation of power for water pumping, irrigation or other purposes.
Survey of possible supply of wood for generating power.
Introduction, for trial, of simple systems of power generation.

Small scale plywood and veneer production
Survey of potential raw material.
Survey of consumption and potential markets.
Investigation of small scale, possibly second hand machinery available and techniques of simple production.
Introduction and trials of machinery.
Establishment of pilot industries.

Small scale fibre board production
Survey of possibly raw materials.
Survey of potential consumption.
Investigation of small scale machinery available.
Introduction and trials of suitable machinery.
Establishment of pilot industries.

Methods of using wood residues
Survey of existing uses of wood and bark residues.
Survey of possible methods of using any which are not fully utilised and potential markets for the products.
Introduction of suitable equipment to use the residues available.
Establishment of commercial operations using the residues.

"Exports" and Marketing from local communities
Survey of possible wood products which could be made from existing wood resources in local communities and "exported" either to neighbouring communities or towns or overseas to provide a cash income for the community.
Introduction of techniques of manufacture and marketing to produce and sell these products.
Dissemination and Training

Other activities necessary for widespread application of suitable technologies are:

Investigation of the role of local organisations and control of resources, including land tenure.

Investigation of the role of women in forestry and forest resource use.

Identification of training requirements and development of appropriate training packages.

Investigation of the role and need for credit, methods of obtaining it and assistance to entrepreneurs.

Examination of the effect of government fiscal policy e.g. pricing, subsidies and import duties which may effect the economics of local manufacture of equipment and processing.

Integration of social forestry and other forestry schemes with small industry development.

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Requests for any publications reviewed or noted below should be addressed to the appropriate publishers and not to the Association.

**Multipurpose Tree Germplasm.** Edited by J. Burley and P. von Carlowitz. Published by the International Council for Research into Agroforestry, P.O. Box 30677, Nairobi, Kenya, 1994 xvi + 298 pp. Free on application, postage contribution appreciated.

As deforestation continues to increase, especially in the tropics, with consequent land degradation resulting in acute food and fuelwood supply problems, organisations the world over are aware that intensive counter-measures are needed quickly to protect the environment. This book states there is growing awareness that woody perennial species will play a prominent role in providing not only fuelwood and structural timber but also many other products on these sensitive or degraded lands, that is, ‘Multipurpose’ trees will become increasingly important.

This book contains the proceedings of a Planning Workshop which gathered to discuss the problems that may arise from the increased use of a multitude of little-known ‘multipurpose’ trees. The Workshop brought together scientists, experts and donor representatives from around the world. The objectives of the Workshop were to describe current activities and problems; and to provide strategies and recommendations to combat them.

The book starts by giving a summary of recommendations and proposed programmes of action. Basically the conclusion is that there must be international cooperation on all aspects of research, development and utilisation of multipurpose tree species. When one looks at the list of the 50 or so organisations (and their abbreviations given in Section 5) that have some interest in multipurpose trees it becomes apparent that cooperation and meetings like this are essential to prevent duplicating effort which puts a strain on already limited funds. The Workshop considered the usual activities required for the rational development of the genetic resources of any species — exploration, evaluation, conservation and utilisation, and data storage, retrieval and dissemination — and suggested organisations which might carry out these activities.

A main problem is the vast number of potential multipurpose trees (5 pages discuss the definition of multipurpose trees, i.e. trees with more than one use!) which could be developed and utilised. The Working Group recommends the production of a short list of priority species for each of 3 ecological zones: semi-arid and arid; sub-humid; and humid. A procedure for this priority assessment is outlined in Section 3.

Much of the book consists of background and support documents prepared for the Workshop and considered by the Working Group. They include papers on ‘Global Needs and Problems of Collection, Storage and Distribution of Multipurpose Tree Germplasm’ (J. Burley); ‘Plant Health Legislation and Forest Trees’ (M. H. Ivory); and ‘Tree Seed Supply’ (J. W. Turnbull) amongst others. Burley’s paper takes up most of this section, (one third of the whole book) and contains a dazzling array of appendices on possible multipurpose species which could be planted about the world (and in specific areas), their uses, organisations already working on multipurpose trees, amount of deforestation and so on.

The book is really a statement of fact; these are the problems. what are we going to collectively do about them? It reports on the first international forum of this kind and therefore becomes something of a definitive document for all organisations and students with an interest in this area.

S. J. Lee


This newest assessment of the forest resources of Europe, the USSR and North America has been prepared under the auspices of the joint FAO/ECE Working Party on Forest Economics and Statistics, a subsidiary body of the FAO European Forestry Commission and the ECE Timber Committee. Detailed forest inventory information is given for the 32 countries in the region which accounts for roughly half of the world’s forest area.
The respective areas of forest and wooded lands and their exploitable growing stocks are as follows: Europe — 181 M ha, 74% exploitable closed forest with an over bark growing stock of 16,000 M m³; The USSR — 930 M ha, 57%, 67,000 M m³; North America — 734 M ha, 56%, 46,000 M m³. The percentage of public ownership is 53% in Europe, 100% in USSR, 68% in North America.

The publication is in three parts:

Part I. Inventory, land and forest ownership, management and classification.
   Exploitable growing stock, its annual increment and annual fellings and removals.
   Age, class, distribution of the main exploitable species.

Part II. National estimates of the weight of biomass.

Part III. Environmental and other non woods, goods and services.

UN Information note
Arboreal Marsupials and Foliar Nutrients in Eucalypt Forests of Australia by T. W. Norton, Department of Forestry, The Australian National University, Canberra ACT

Appropriate management of forests for wildlife is now an accepted, albeit problematic, goal of forest managers throughout much of the world. Recent studies by L. W. Braithwaite (Aust. Wildl. Res. 1983, 10: 219–29) in several production eucalypt forests of south east Australia provide new insights into the ‘link’ between forests and tree-dependent wildlife. These studies indicated that all the arboreal marsupial species (possums and gliding-possums) and the majority of animals of each species were concentrated within a limited number of the eucalypt forests investigated and that an index of foliage nutrient (nitrogen, potassium, phosphorus) concentration of these forests was the major determinant of density and species richness of these animals.

To test some of Braithwaite’s hypotheses the author undertook a doctoral study to examine the relationship between forest foliage quality and density of the most folivorous arboreal species, the Greater Glider *Petauroides volans*. This study, as reported in Bull. Aust. Mammal. Soc. 1985: 9, supports Braithwaite’s conclusions. Population distribution, size and status of *P. volans* was primarily influenced by the quality of the eucalypt forest habitat. Quality habitat was defined at the eucalypt community level and was considered to be those communities: (a) represented by tree species with a suitably high concentration of mature eucalypt foliar nutrients (N, P, K), and (b) of suitable area to support animals. Availability of nesting hollows in trees was not considered a limiting factor in the forests studied.

Since edaphic factors, especially the type of soil parent material, markedly influence the distribution pattern of these eucalypt communities (Braithwaite, L. W., Turner, J. and Kelly, J., Aust. Wildl. Res. 1984, 11: 41–9) it is suggested that potentially important eucalypt communities (or arboreal wildlife habitats) may be delineated by the combined use of aerial photographs and LANDSAT imagery. Ground-truthing could then determine the significance of these forests for the long term conservation of these species. This approach is currently under examination. Nutrient ‘pools’ have also been implicated in accounting for the distribution of small mammal species in the rainforests of north east Australia (Barry, S. J., Aust. Wildl. Res. 1984, 11: 31–41) and also are important ‘indicators’ of the distribution of wildlife in other forests of the world, particularly in relation to herbivores and folivorous primates.

Other applications of this data may prove beneficial to forestry (eucalypt) plantation managers both in Australia and overseas, for example Brazil and China. Browsing by wildlife in young plantations may be retarded by laying ‘nutrient’ baits laced with toxins (*e.g.* 1080: sodium fluoroacetate). These baits could be relatively species specific if some knowledge of the seasonal nutritional requirements of the indigenous browsing animals is available.
With steam or thermal fluid system.

Electric heating or hot water.

Large, medium or small capacity.

Long-proven aluminium construction.

Semi or full automatic control.

Direct gas fired kilns with rails & bogies or direct loading to hold maximum throughout.

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