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Australian Forestry 1988

The Review has given me, R. L. (Bob) Newman as guest writer of this editorial, a challenging task to cover Australia's position in Forestry. As many of the readers will know 1988 is the Bicentennial year of the arrival of European settlement to Australia and it is fitting to review achievements in all spheres of endeavour not the least being forestry.

The indigenous forest cover is unique to Australia barring some 'beech' (*Nothofagus* spp.) forests in Southern Tasmania and some residual Tropical rain forest in North Queensland.

The Eucalypts (Hardwood) belonging to the family Myrtaceae dominate the native forested area of some 41,000,000 hectares (5% of the total land mass) both in area and range of species — over 600 in all. In the temperate rain forest-cum-wet sclerophyll forest the famous Red Cedar (*Cedela toona*) existed extensively on the arrival of the white man. It was good timber for joinery, light in weight with a very pleasing appearance, but used rather indiscriminately by the first settlers, who seemed to think there was an unending supply. Although still much sought after it is now hard to find.

The western forested plains of Eastern Australia has 4,000,000 hectares with Cypress Pine, another indigenous species, whilst over 600 species of Acacias, some Casuarina species and Hoop Pine (*Auracauria* sp.) make up the balance of the major forest scene.

Oregon timber (*Pseudotsuga taxifolia*) imports dominated Australian construction work for the first 150 years — imported both from the USA and Canada; and only the exigencies caused by the late 1800's population increase and the first world war caused intense interest in the Australian Hardwood resource. At the same time, because of the early foresters’ efforts to reserve good tracts of Crown land for permanent forests, Forest Management commenced in earnest.

In the late 19th Century South Australia, devoid of commercial forest cover, commenced to grow *Pinus radiata* introduced from the Californian coast of the United States of America. It grew so successfully that other Australian states, notably New South Wales and Victoria, commenced establishing *Pinus radiata* plantations.

The post First War period saw the formalisation of Public Sector forestry in the form of Forestry Commission with foresters commencing to obtain their training in Australia. The School of Forestry at Creswick commenced to train Victorian students in 1910 and is now part of the Department of Forestry at the Melbourne University; at the same time the foundation of the Department of Forestry at the University of Adelaide occurred.

The latter, in 1927, transferred to Canberra under the direction of Mr. C. E. Lane Poole, a Nancy graduate, and subsequently after an outstanding period of teaching by Dr. M. R. Jacobs became, in 1966, the Department of Forestry at the Australian National University.

During and after the Second World War with better forest access using earthmoving equipment, together with chain saw cutting, pulp and paper companies were able to flourish, particularly in Tasmania. Substantial technical help was provided by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Concurrently, the Native Forest Sawmilling Industry expanded with better access to cope with the post war building boom.

The *Pinus radiata* and Southern USA Pine specie plantings received a boost from...
federal government support in the 1960's and early 70's and today over 40% of the sawn timber production is coming from Pinus radiata and other exotic Pine species. The Plantation estate has reached over 0.74M ha.

The 1970's and 1980's has seen the development of a greater awareness of forest ecology and pressures from the conservation movement and the forestry profession itself have caused changes in the management of our forests. For instance the period has seen the change in status of nearly 1M ha of production forest to National Park use. This has caused a reduction of some 20% of the better classes of native Eucalypt forest available for utilisation.

The introduction of Forest Practices guidelines for utilisation has had important and useful environmental effects.

Management changes are continuing to be applied and as recently as December 1987 discussions between the Forest Industry and the Prime Minister took place in order to ensure the industry has access to sufficient hardwood forests on a sustained basis.

The CSIRO sections of Forest Research and Forest Products Research, have joined forces in 1987 and this re-organisation with an increasingly strong private sector interest in forest establishment and management, will be making a major contribution to the future success of forestry.

The Public Forestry sector throughout Australia continues to be well served with dedicated men and women with increasing professionalism and technical competence to handle both environmental and production matters. It controls by far the largest proportion of identified production forests in the Country.

The emergence too of a stronger private sector should result in Forestry and Forest Products maintaining its place as Australia's second largest industry. So with the Bicentenary being celebrated and a first class Forestry Conference in April to review achievements, we are looking forward to the next 200 years of contributions to forestry in and by Australia.

Commonwealth Forestry Association Meetings in 1988

April 29  At Albury, New South Wales; reception for members and friends, early evening.

May 26  A.G.M. Forest of Dean, Gloucestershire, UK: Executive, Governing Council 10.15 AGM Noon, Lunch, afternoon, broadleaves with the Commission, Bells, Dinner at Speech House, followed by ODA film on Nepal.

27  Visit to Formwood, Coleford, conifers with the Commission, Lunch at Little Dean, Huntley Forest Products, Woodland Improvement, Forest Gate.

June 27  CFA Open House at the OFI during the forum on The Future of Tropical Rain Forests

28  ditto

September 29  New Forest, Executive in morning, lunch at Lyndhurst, afternoon in the woods.

November 12  Albury, New South Wales; meeting at noon in the Commercial Club.

References on Honduran Pine

Margaret S. Devall, US Forest Service, Southern Forest Experimental Station, IQS, Room T-10210, 701 Loyola Avenue, New Orleans, Louisiana 70113 has asked scientists who have written on the above subject to let her know of their publications as she is preparing a bibliography on the species.
THE QUEEN'S AWARD FOR FORESTRY

There were 35 nominations for the first Queen's Award for Forestry. These names were considered by the Australian Committee which had representatives of 12 leading Australian forestry organisations and the Association's Australian Local Honorary Secretaries. The proposed recipient, approved by the Australian members of Governing Council is Dr. John Wright Turnbull.

Dr. John Turnbull is a graduate of the University of Wales and the Australian National University. He commenced his career as a forester in South Australia and subsequently worked as a scientist in the Forest Research Institute and as a professional assistant to the Director General of the Forestry and Timber Bureau. He served as leader of the Tree Seed Centre of the Forestry Program Co-ordinator of the Australian Centre for International Agricultural Research (ACIAR), also editing the ACIAR Forestry Newsletter. He has been principal author of several books on Australian trees and contributed numerous articles based upon his experience with eucalypts and with nitrogen-fixing trees. In his internal and international committee work with FAO, IUFRO and ACIAR he has been an exemplary ambassador for forestry and for Australia. Her Majesty has graciously agreed to present the Award at Melbourne on the 29 April.

The runner up for the first award is Dr. Don Gilmour, who is manager for the Nepal-Australian Forestry Project and was inaugural Principal of the Queensland Forestry Department's Training Centre at Gympie.

It is intended that the Second Award should be presented to a forester from any Commonwealth country. However, the award will celebrate the 13th Commonwealth Forestry Conference. This will be held in Rotorua, North Island New Zealand between the 18 and 29 September, 1989. The financial side of the Award will take the form of a travel Fellowship to other Commonwealth Countries to provide opportunities to further a career and its impact around the world. If the final decision has to be made between two comparable candidates, the popular one would have an itinerary which justified being in New Zealand at the time of the Conference, either en route to a project elsewhere in the Commonwealth or having arrived with a programme which benefitted from being in the South Pacific. Whilst other scenarios would not be excluded, the recruitment of funds for the 1989 Award would be facilitated if the winner could justify being in Rotorua to receive the award during the Conference.

The Association's Executive Committee would need to have forwarded the details of the proposed recipient of the second Award to the Palace by the end of June, 1989; this suggests that names of candidates should be with the Executive Committee — care of the Secretary — by the end of May '89. Each Local Honorary Secretary and member of Governing Council will be able to forward the names, c.v. and proposed location and aspects of forestry experience to be studied of up to two potential candidates. The candidates should be in mid-career, having already made their mark in some aspect of the broad field of forestry or forest utilisation, they should be sufficiently articulate to communicate their experience to the benefit of the community.
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CORRESPONDENCE

Ex-Chief Conservator of Forests,
Orissa
Kiligali
Cutack 753 002
India

Dear Sir,

A reference is invited to the letter of Mr. Graham Tuley in the September issue of *The Review*. I very much appreciate his idea of forging a sense of togetherness amongst the foresters of the Commonwealth. It is particularly important at this time as the present day ‘environmentalists,’ instead of advancing the cause of forest conservation and forest resource mobilisation for the benefit of Society, they have set their faces against the basic concept of forest management. A very disturbing and undesirable trend being publicised has been to decry the forester and his work in an attempt to expand their own image. The ‘environmentalist’ is failing to realise that the forests have several functions to fulfil and that environmental amelioration is but one of them.

In a recent issue of an important Daily published in South India, a noted ‘environmentalist’ has observed that the “Chipko Movement” has shown that Forest Working Plans prepared and supported by technical experts are wrong. However, the Daily gives no justification as to why the forester’s recommendations should be overturned.

The Commonwealth Forestry Association has an important role to play in upholding the traditional value of forest management and in refuting the spurious arguments of so-called environmentalists.

I hope the Standing Committee on Commonwealth Forestry will make an opportunity for this subject to be aired at the next Commonwealth Forestry Conference in New Zealand.

Yours truly,
B. L. DAS
c/o Groome Pöyry Ltd
P.O. Box 169
TAUPO
New Zealand
28 January 1988

Dear Sir,

**RE: SITE INDEX CURVES FOR TEAK —**

C.F.R. VOLUME 66(3) No. 208 September 1987

I read the above paper by Kathleen Friday with considerable interest, and having undertaken similar assessments in the Solomon Islands and observed the growth of Teak in Java and some Pacific Islands, I would like to take this opportunity to provide some additional background material; which may or may not be germane to the author’s findings.

Perum Perhutani manages approximately one million hectares of Teak plantations on Java and their mensurational data has produced height/age curves from which are
### TEAK — HEIGHT/AGE TABLE

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Site Class</th>
<th>Average Height — metres</th>
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<td>I</td>
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(Source: Lembaga Penelitian Hutan — 1975)

derived 5 Site Index Curves. Copies are appended. Crops are close planted, have rotation lengths of approximately 80 years, with production thinnings proposed every 10 years.

Perusal of the Site Index curves for Puerto Rico and Burma Teak indicates that height increases fairly uniformly with age to about 27/28 metres at age 50; this is in marked contrast when these curves are compared with those of Trinidad and the Caribbean/Central Region when height growth is rapid at first but then tails off markedly to 21/22 metres at about age 50. The shape of the Java curves is of the second type, though the geology, pedology and nutrient factors may be somewhat different.

My personal opinion is that Site Index curves showing a marked tailing off in height increment should be expected from assessments in plots established in plantations of Teak and other hardwoods. In contrast if height increases fairly uniformly with age one is more likely to be dealing with data from conditions that approximate much more closely to native forest.

I would like to inspect current and future data from Puerto Rico especially in relation to planting parameters as espacement at various ages is a very important component for Site Index and can be used to manipulate the growth of a stand.

Yours faithfully

K. D. Marten
**NEWS OF MEMBERS AND FRIENDS**

*Dan Alexander*, Chief Executive Officer of St. Mary's Paper in Sault Ste. Marie, has been awarded the *B.J. Smith Memorial Award*. This is in recognition by the Ontario Section of the Canadian Institute of Forestry for Mr. Alexander being largely responsible for salvaging the former Abitibi-Price Paper Mill and making it once again a viable industry.

*Professor Ernest Arthur Bell* is congratulated on becoming a Commander of the Bath. His kind hosting of the Association’s September ’86 meeting was quite co-incidental to the award of the honour. Many letters of sympathy followed the felling of so many majestic trees by October’s hurricane; members of the timber trade were amazed that such fine logs should be cut into short lengths.

*Ian Boyd*, graduate of Canterbury, as General Manager of Tasman Forestal, a Chilean subsidiary of the New Zealand Fletcher Challenge Group. He has an employed staff of 60, a further 1,500 part time contractors whilst the Group’s Papeles y Bosques Bio Bio employs a further 350 for their pulping and milling operation.

*E. Clicheroux* (Belgium) has been elected Chairman of the European Forestry Commission. Three Vice-Chairman elected were B. Berdar (Hungary), O. Aalde (Norway) and J. M. A. Soares (Portugal).

*Ernest M. Gould*, who had dedicated many years of service to Harvard University, died on January 8, ’88. He was Forest Economist, Senior Lecturer on Biology and Assistant Director of the Harvard Forest.

Three erstwhile graduates of the Australian Forestry School at Canberra meet at the Jubilee session of the Institute of Foresters of Australia, Perth 1987

Fred Hoschke, (Chief of the NSW Forestry Commission Fire Protection Division)

Bob Newman, (Director of R.L. Newman and Partners Pty Ltd.)

Peter Hewett, (Director of Forests for West Australian Government Conservation and Land Management Department.)
Jim Henderson joined the Forestry Department at Aberdeen as an undergraduate after six years war service in the RNVR. In 1964 he retired as Conservator of Forests for the southern region of Nyasaland (Malawi). He was appointed lecturer in Harvesting and Marketing at Aberdeen where he also served as a Lieutenant Commander in the University's Royal Navy unit. He is a past President of the Royal Scottish Forestry Society. He is wished a happy retirement with his wife Patsy in the Shetlands.

Charles L. Henry, Director of the 'Forest Sludge Program' at the University of Washington is one of the editors of “The Forest Alternative for Treatment and Utilization of Municipal and Industrial Wastes”. Some of the 51 papers brought together under stiff backed covers include ‘Irrigation of tree plantations with recycled water in Australia’, ‘. . . Slash pine land treatment’, ‘Response of Loblolly pine to sewage sludge application’, ‘Affect of sludge on concentration . . .’ of small mammals’ and ‘Nitrogen transformation in four sludge-amended Michigan forest types’. Recent visitors to the ‘Flow’ country in North-East Scotland may have recognized the latter as good conservationists.

Ian Hunter, of the Forest Research Institute at Rotorua, investigated tree nutrition on Fiji and concluded that the lack of needles on some pine shoots and multiple pine branching might both be associated with boron deficiency.

John Jobling, who joined the UK Forestry Commission as a District Officer at Alice Holt Research Station in 1950 died on October 13. He was a PSO in the Research Division and will be remembered for his work, among other aspects, on poplars and the establishment of restored land.

Professor R. J. Johns has been appointed Head of the Forestry Department at the University of Technology in Papua New Guinea. Some 20 years ago he was at the Forestry College at Bulolo and has spent the last 8 years at the University. The former Head, David Wigston, is now working in Australia.

John McEwan, OBE, a past president of the Royal Scottish Forestry Society, celebrated his 100th birthday in September.

John G. Murray, Vice-President of Woodlands of Crestbrook Industries has been elected Chairman of the B.C. Forestry Association Forestry Education Board. He succeeds Grant L. Ainscough (Chief Forester and Vice-President of MacMillan Bloedel Ltd).

Mike Philip took time off from Aberdeen for a trip to Sarawak and met many past students en route. He stayed with Chung Kuch Shin (MSc 75) and was joined by Ong Cho Chew (MSc 77), Joe Kendawang (BSc 82) and Andrew (Salang) Tukau (BSc Hons. 86). On his travels he met Ling Wang Choon (74), Elbsom Pengiran (80), Abang H. K. Morshida (72) and Philip Jalang (73). He missed Ali Yusup and Sylvester Tong, but spoke to Lai Khim Kuet (73) on the 'phone. He brought back the good wishes of Cecil Pang who graduated from Edinburgh with an MSc in 74.

A. G. Philips, who has long been involved with the Association of Professorial Foresters is congratulated on his award of the OBE.

Dr. Reino Pulkki, who obtained his degree at Helsinki before joining Jakko Pöyry, is taking a teaching post in Forest Harvesting and Transportation at Lakehead University.

E. G. (Dick) Richards has edited reports from 26 countries on the theme ‘Major developments in the forest and forest industry sector since 1947: lessons for the future’.
These reports were presented to the Economic Commission for Europe. The publishers are Martinus Nijhoff, PO Box 163, 3300 AD Dordrecht, the Netherlands.

Gordon Simpson, Head Forester with the UK Forestry Commission is congratulated on being awarded the MBE in the New Year Honours. His enthusiasm for the diverse wild life in the forests around Durham is brought to the attention of the public with the attractive second issue of the Commission's Forest Life. The forests provide a habitat for a wealth of insects, some of which in turn support local populations of 140 species of bird. Some such as the crossbill, redpoll, siskin, goshawk and sparrowhawk have come back in large numbers to Britain, as a direct result of the planting programme establishing conifers.

J. Säglitz (GDR) has been elected as Chairman of the ECE Timber Committee and as Vice-Chairman, Mr. H. van der Meiden (the Netherlands). The Committee is mainly concerned with the wood-processing industries and trade for forest products. It was conceived at the 1947 European Timber Conference at Marianski Lazne in Czechoslovakia in 1947.

Tom Vigus has returned to Australia after six years teaching at the University of Technology in Papua New Guinea. His successor is That Chi Liew who is on leave from Sabah and had been working in Australia.

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J. B. Bryce

John Magarey (‘Jock’) Bryce died of a heart attack on 3rd July 1987, at Gifford, Scotland. He was a few weeks short of his 66th birthday.

Jock’s father was a Scot and his mother Australian, and he maintained dual nationality throughout his life. He was educated at Felstead and Pembroke College, Oxford, where he read English at the beginning of the war and Forestry after it. In between he served in Coastal Command of the RAF. He was shot down in the Mediterranean, succeeded in getting out of the cockpit under water and was greeted by the exultant Italian skipper of the ship he had attacked with the words “Mare nostrum!” He spent three years as a prisoner-of-war. Part of this time was in the huge Carthusian monastery at Padula in southern Italy, which he took pleasure in revisiting as a tourist thirty years after. Later, as a POW in Germany, he took part in an exhausting march westwards as camps were evacuated in face of the Russian advance. Weary as the prisoners were, they were still able to help in carrying the rifles of their elderly and still more weary German guards. By the time of his release Jock was a first-rate bridge player. The stakes were the highest in his life — a single knob of chocolate!

After taking his honours degree in forestry at Oxford in 1949, Jock joined the Forest Department in Tanganyika, as it then was. His first posting was to the Southern Province, then the least developed part of the country, where he was responsible for opening a new forest station on the Rondo Plateau. He supervised the harvesting of overmature Chlorophora stands and initiated work on their regeneration and management. He also started trials of other species, including the first introduction of teak to the Rondo. Elsewhere in the Province forest reservation was the top priority, involving long foot safaris in roadless country.

After a short spell in head office in Morogoro, he joined the Utilisation Section in Moshi and succeeded Fred Hughes as Utilisation Officer in 1959. He carried research on logging in the varied and often difficult local terrain and on the working, seasoning and preservation properties of a number of indigenous and exotic species. This culminated in the 1967 publication of his book on “The Commercial Timbers of Tanzania.”

On retirement from the Tanzania Forest Department, Jock joined FAO and came to HQ in Rome in 1968. He spent an initial period with the Forest Industries Division and then moved to the Forest Operations Service, where his talent for administration and swift decision were invaluable. He was in charge of projects in the Africa, Near East and Mediterranean areas, with some additional projects in the Far East. He retired from FAO in 1983.

Jock enjoyed playing cricket, tennis and golf. He was a keen gardener and, after buying a small country property near Todi, where friends were always welcome, he merged gardening with forestry by becoming an enthusiastic olive grower. He had a brilliant, astringent wit and, in particular, a gift for instant, apt repartee. At one especially tedious international meeting he intervened with “Mr Chairman, the last speaker split an infinitive!” He could pass from the purest of Oxford accents to broad “Strine” or broad Scots without moving an eyelid. For his old friends no kindness or hospitality was too much.

He married his first wife, Anne, in 1949. They had four daughters. She died in 1969. He married his second wife, Clare, in 1972. Our deepest sympathy goes to her and to his daughters, Jane, Mary, Alexandra and Sally.

R.L.W.
Mr. Geoffrey Walter Chapman

Geoffrey Chapman, a professional forester who made an outstanding contribution to forestry development in the Middle East, died on 1st January, 1988 aged 79 years, after a long illness.

Geoffrey Walter Chapman was born on 1st December, 1908 and was educated at Cranbrook School in Kent and Cambridge University where he obtained his B.A. Dip. Forestry in 1929. In 1930 he was appointed to the post of Assistant Conservator of Forests in Cyprus, a first introduction to the forestry and land use problems of the Middle East which were to exercise his attention and interest for the whole of his professional career. In Cyprus his ability and industry as a planner and initiation of new ideas were clearly evident, both in his activities in the field as District Forest Officer and at H.Q. in Nicosia where he eventually became Conservator of Forests and Head of the Forest Service. During the War years he became Operations Officer in Cyprus for Force 133, a wing of S.O.E. which was engaged in the conduct of covert operations against the enemy in Greece. For this service he was awarded an M.B.E.(Mil.)

His first professional experience outside Cyprus came in 1947 when he was seconded for three years to Iraq as Director of Forests. In 1950 he was seconded to the Foreign Office as Forester and Land Use Adviser in the British Middle East Office in Cairo, from which vantage point he played an active role in encouraging the newly emerging interest in forestry development which was then becoming manifest in a number of Middle Eastern countries. He returned to Cyprus to become Conservator of Forests in the spring of 1951 and relinquished his post in 1955 to return again to Iraq, this time on secondment to F.A.O. as Chief Forestry Adviser. He finally retired from the Colonial Service in 1958 and thereafter served continuously with F.A.O. in a variety of senior posts in Turkey and Morocco until 1963 when he retired to a farm in Wales. There he threw himself with characteristic enthusiasm and energy into improving his property and participation in a range of communal farming and forestry activities. He also continued his links with F.A.O. and undertook a number of consultancies from that organisation, mainly in the Middle East and North Africa.

He was a man whose lively mind and intellectual curiosity persisted throughout the passage of the years. He leaves many personal and professional friends who will be saddened at his passing. He is survived by his wife Esther and sons Mark and Timothy.

D.F.D.
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25/ 4/88– 1/ 5/88 AUSTRALIA, Albury. Australian Bi-Centenary — Eucalypts,
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29/ 4/88 CFA Reception at Albury (check time, scheduled for 6pm.)
Ref: R. L. Newman, AFDI, PO Box 515, Launceston, Tasmania 7250.

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Ref: AAB, Inst. of Horticultural Research, Wellesbourne, Warks CV35 9EF.

Ref: J. Dargavel, Cres, Australian National University, GPO Box 4,
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for Development’. (Candidates should be graduates working for a
national institution).
Ref: Training Officer, PO Box 30677, Nairobi, Kenya.

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Ref: H. Rosen, Forest Service, PO Box 96090, RPE, Washington,
D.C. USA.

16/ 5/88–18/ 5/88 AUSTRALIA, Canberra. Changing Tropical Forests. IUFRO
S6.07–01.
Ref: J. Dargavel, C for RES, Australian N. University GPO Box 4
Canberra, ACT 2601, Australia.

Ref: M. T. Rogers, CA, OFI, South Parks Rd., Oxford OX1 3RB.

IUFRO S2.07–07.
Ref: H. Schmutzenhofer, Forstliche Bundesversuchsanstalt, A­1131 Wien Austria.

14/ 6/88–16/ 6/88 SWEDEN, Umeå. Molecular Genetics of Forest Trees.
Ref: Dr. Jan-Erik Häggren, Dept. of Forest Genetics, Swedish
University of Agricultural Sciences, S–901 83 Umeå, Sweden.

20/ 6/88–24/ 6/88 MALAYSIA, Kuala Lumpur. Moist Tropical Mixed Forest,
Yields.
Ref: Wan Razali Bin Wan Mohd, FRI, Kepong 52109 Kuala
Lumpur, Malaysia.

Ref: M. McDermott, OFI, South Parks Rd., Oxford OX1 3RB.

27/ 6/88–30/ 6/88 CANADA, Victoria BC. Cone and Seed Insects IUFRO S2.07–
01.
Ref: A. Roques, INRA-CRF, Station de Zoologie Forestiere,
Ardon, F-45160 Olivet, France.

28/ 6/88–30/ 6/88 USA, Connecticut. Lymantriiid Populations IUFRO S2.07–06.
Ref: W. E. Wallner, NEFES, Center for Biological Control, 51
Mill Rd., Hamden, Connecticut 06514, USA.
3/ 7/88– 9/ 7/88 CANADA, Vancouver. 1st International Conference on Classification, Phylogeny and Natural History of Scolytidae. Ref: D. E. Bright, Biosystemics Research Centre, Canada Agriculture, K. W. Neatby Building, Ottawa, Ontario, Canada K1A OC6.


19/ 9/88–22/ 9/88 USA, Seattle. Timber Engineering '88. Ref: Dr. R. Y. Itani, Dept. CEE, Washington State University, Pullman, WA 99164–2914, USA.


2/10/88– 8/10/88 SWITZERLAND, Interlaken. Air Pollution and Forest Decline, IUFRO. Ref: W. Baltensweiler, Institut für Phytomedizin, Clausiusstrasse 21, Ch-8092 Zürich, Switzerland.

18/10/88–22/10/88 INDONESIA, Jakarta. Forestry and Woodworking Exhibition. Ref: PT Pamerindo Buana Abadi, c/o N. West, Overseas Exhibition Services, 11 Manchester Square, London W1M 5AB.


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AROUND THE WORLD

BOTSWANA

A land locked plateau country of 600,372 km², intermediate in size between its smaller north eastern neighbour Zimbabwe and larger northern neighbour Zambia but its 1 M population being less than 15% of either of them; previously it was known as Bechuanaland. Some 84% of the country is semi-desert, part of the Kalahari, but the woodland is concentrated in the north east of the country and around the Okavango Delta, some 400 miles north west of the Capital, Gaborone.

The following details have been gleaned from the 100 pages of the Forestry Association of Botswana’s Journal for 1986–87. Amongst the authors are included David Inger, their Association’s President and founding father and Dr. Colin Millar, who at the time they went to press was on secondment from Aberdeen as Director of a staff of 10.

The Kasane Forest Reserve (16,250 ha) was declared in 1968 and a further five reserves, all in the same Chobe District in the north, brought the reserve area in 1981 up to 455,500 ha. Although the mainly open woodland is lightly stocked at 1.5 to 4 m³ per ha this still represents over 1 M m³. ‘Exploitable’ timber on two of the reserves offers 300,000 m³ on 300,000 ha but this appears to relate to timber which is up to an economic size rather than some correlation with annual increment. Figures which are available over the last 50 years show the following royalties:

1935–38  40,000 m³ sold in the round to Rhodesia (Zimbabwe) and South Africa,
1945–55  150,000 m³
1983–87  33,552 m³ (but 30,000 m³ extracted from Kasane Extension in ’86).

The main species in the north is *Baikieae plurijuga* (mukusi or ‘African teak’), further east and south (but still in the north east of the country), the dominant or most represented economic species is *Pterocarpus angloensis* (Mukwa or ‘African camwood’).

One of the recommendations from the ‘Teak Forest Conference’ held in Livingstone, Zambia in 1984 was that exploitation should be reduced until the specie’s regeneration and its rotation were better understood to allow a sustained yield.

A World Bank Mission emphasised the value which the forest reserves contributed towards the husbanding of game. The continued increase in the elephant population is already creating localised problems in forest management. Much of the open forest is the result of sporadic burning; deliberate light burning for ‘range improvement’ can minimise the risk of fires such as the 1984 one which burnt 20,000 ha.

The species which was chosen with the promise for plantation work was *Eucalyptus camaldulensis*. One of the best plantations in the country at Molepolole, initiated in 1973, is failing to produce the anticipated returns of 9–18T per ha annually but at a figure between 1 and 2 T/ha/annum is just comparable with the unmanaged local vegetation. There are three apparent explanations, termite damage, theft and drought; standing dead poles increase in percentage of those planted from 10% at 8 years to 50% at 10 years. The dead trees, *in situ*, suggest that the problem is not theft. Older, taller trees suffered during the severe drought of 1984 with a significant death rate being recorded by November ’85. There may be other strains of *E. camaldulensis* better equipped to cope with Botswana’s periodic severe droughts but it is also worth assessing some indigenous trees in plantations, in particular *Acacia tortilis* which is locally common, acceptable for grazing and firewood and has been grown commercially in India. Survival at the end of one year’s trial, *A. tortilis* gave 85% survival, *A. karroo* 41%, *A. erubescens* 36.3% and *A. erioloba* 25.6%.
Those interested in further details are invited to write to Dr. Tabe Tietema, FAB, PO Box 2088, Gaborone, Botswana, Africa.

CANADA

The Canadian Council of Forest Ministers has published its fourth issue of Forestry Forum. The first issue gave the Canadian public an insight into the relative importance of their forest industry internationally. This Winter '87 '88 issue highlights the significance of forestry in each province. In addition to this circulation of the printed word, the Atlantic provinces have combined to produce three television commercials, the Central provinces have produced television material in French and English and British Columbia has allocated $75,000 for projects by non-profit making organisations to promote forest awareness. Whilst each of the Ministers emphasises the attention being paid to sustaining the forest resource, conservation and amenity, it is the details of forest management which have been extracted for the Review.

British Columbia

Commercial forests cover 52M ha, 55% of the province which also has 2M ha of fresh water. The volume of mature timber is in the region of 8 billion m$^3$ of which 97% is conifer, this is 40% of the Canadian inventory, 20% of the North American resource. The 1986 harvest was 77.5M m$^3$ with 24% of it being *Pinus contorta*, slightly less *Picea* species, *Tsuga*, *Abies*, *Pseudotsuga* and *Thuya* at 10.3% in descending order of importance. The value of exports from the province for 1986 amounted to $5.5 billion for the wood industries and $3.9 billion for paper and allied industries. This represented 46% of the total manufactured provincial exports. The chief destination was USA at 57.2% followed by Japan 16% and Europe just under 16%. The B.C. government owns 94% of the forest, private interests 5% and the Canadian government 1%. The 1988 planting programme will use 200M trees and rely on natural regeneration for the other 40% of area to be restocked. During the last 10 years 10,000 B.C. educators have received teaching material under the Project Learning Tree. Further details of the scheme which is supported by American, Canadian and Swedish educational and forest organisations may be obtained from Barbara Jones, BC Forestry Association 1430-1100 Melville Street, Vancouver BC. V6E 2A6.

Alberta

The mountain forests of The Eastern Slopes cover 55,000 km$^2$. Interests other than commercial logging take priority over 27% of the forest. The areas of ‘old growth’, about a fifth of the forest, suffer from the effects of fire, insect attack and fungal disease; some over mature trees have to be removed if desirable habitats are not to be lost. Controlled burning may be required to minimise the damage from wild fires and to improve the subsequent conditions for elk, deer and moose. The Alberta Forest Service caters for the whole gamut of users of the forest, for those areas restricted for water catchment and pedestrians to the rapidly developing forest industries. The latter employs 9,000 directly and a further 20,000 indirectly; the forestry sector generates $900 M a year for the provincial economy. $600 M has been invested in forest industry during the last two years with an orientated strand board plant now in production, a medium density fibre board plant and a chemical-thermo-mechanical plant under construction promising employment for a further 1,400. A further $1 billion for potential forest industries is under consideration. Only a fraction of this investment will be needed to make the forestry sector the most significant force in the provincial economy.
Saskatchewan
Some idea of the size of the forest estate can be gleaned from the 1987 forest fire statistics. Although the year, up to the 21 October '87, had produced 974 fires, 67% over the 5 year average, the report says that only 247,965 ha were lost. This was 39% down on the long term average which is influenced by the 1981 figure of 1,647,782 ha burnt. Dry conditions and dry lightning strikes were the main problems early in the season — it must have been hot to have burnt 70,000 ha of Little Bear Lake. Water bombing aircraft were provided by other provinces under the MARS (Mutual Aid Resource Sharing) scheme.

Traditionally, the forest renewal programme has been implemented by the provincial government. Commercial undertakings had limited security of tenure and treated the forest as a resource to ‘mine’. The policy now adopted is that forest industries prepare and implement regeneration programmes in conjunction with the provincial service. Agreements will be renewed every five years providing the 5 year and 20 year undertakings are proving satisfactory. Weyerhaeuser Canada Ltd. bought the government owned Prince Albert Pulpmill in 1986, the Big River Sawmill in '87 and is now constructing a 200,000 T annual capacity paper mill (‘uncoated free-sheet’). This will increase the current $300 M annual wealth injection into the province’s economy and will increase the 8,000 forest employment with an extra 215 jobs at the new mill.

Fears are being expressed for the native elm population and the 12M cultivated elms from the threat of Dutch Elm Disease. Deaths of elms are being monitored by infra red aerial mapping and the spread of the fungus carrying *Scolytus* beetle is being assessed with the aid of pheromone baited traps.

Manitoba
The forest industry employs 12,000 and the figures for 1984–5 show a sale of $220 M in primary forest products, half of the produce passing into the USA. It has been realised that the rate of forest regeneration has not been keeping up with the areas being logged or lost to fire. Since 1984, the federal forest service has been helping the provincial service. Two nurseries at Clearwater and Pineland were opened with a flourish during the year; these should add an extra 20M spruce trees to the annual replanting programme.

Dutch Elm Disease is affecting 1% of elms in Winnipeg and just under 2% in the second largest town of Brandon. It is less easy to monitor and control the spread through native elms along the river courses into Saskatchewan and the USA but the local public has been mobilised to alert the authorities to any suspected cases.

Ontario
The area under forest is 26M ha of which 66% is covered by Forest Management Agreements and in the balance, the Ministry of Natural Resources is responsible for forest regeneration, either directly or through the companies carrying out road building, harvesting, site preparation and their own regeneration programmes. Since 1980 329,000 ha of forest have undergone regeneration treatment by forest companies. Licences are reviewed every five years and renewed if progress is satisfactory. Although natural regeneration will normally follow harvesting, fire or destruction by insects and disease, forest management can enhance the speed and calibre of recovery. During the '86/'87 season, the Ministry of Natural Resources distributed 2 billion seeds and 155M plants from its own and private greenhouses and nurseries. A Northern Forest Biology Centre has been established on the campus of Thunder Bay’s Lakehead University with a remit to investigate and improve the quality of trees for subsequent generations.
The average annual fire damage over the last ten years has been 234,000 ha burnt in 1,700 fires. The 1986 area was 145,461 ha following 1,099 fires. There were encouraging signs that the depredation being caused by Spruce Bud Worm, Jack Pine Bud Worm and Gypsy Moth were also being curtailed following the two year spraying programme of 1M ha with *Bacillus thuringiensis*.

The forest industry in its widest sense provides jobs for about 150,000 in the province. Considerable public relations effort is invested towards improving awareness and appreciation of the continued importance of the forests. One popular figure who toured the summer shows was 'Woody', the talking tree' with his foliage prepared by the costume-maker of the musical 'CATS', scripts and lyrics prepared by Waterwood Productions in conjunction with the Ministry’s Forest Resources Group and Communications Services.

Quebec

The forest industry is the major manufacturing industry in the province. It employs 80,000 people, 14% of the jobs, it provides 18% of exports and 3.8% of the gross internal product. The government owns 90% of the forest and provided 24M m$^3$ harvested in 1984/85 along with 7.2M m$^3$ from private woodlands. Industry invested $1.3 billion between 1979 and 1984 giving a count of 645 sawmills and 57 pulp and paper mills; the production from the latter in 1985 was 4.4M T. Compared with sawlog input volumes, 50% leaves the mill as chips to provide 30% of the mill revenue.

New forest legislation came into force in April 1987 to “ensure that harvesting and forest management must no longer hinder other possible uses of the forest”. The new system replaces the previous forest concessions, guarantees of timber supplies and puts an end to exclusive rights. Forest companies must now abide by government rules, must agree 20 year plans, complete 5 year plans including appropriate regeneration and must implement agreed annual plans. The government will ensure that regulations are complied with, objectives met, dues paid on timber harvested, companies will pay all costs related to their forest management and will contribute to forest protection. Provided that private owners obtain the status of ‘forest producer’ they may obtain financial and technical assistance and receive 85% reimbursement of their property taxes paid on woodlots managed. It was the lack of adequate regeneration being appreciated in 1986 which forced the implementation of the stricter regime with its additional annual cost of $200 M to be shared between government and industry.

New Brunswick

The 6.1M ha of forest in the province represents 85% of the area and provides 31% of the manufacturing output worth $1.3 billion a year. The 36,000 people who have forest related employment are over 14% of the work force. The Crown owns 48% of the forest which it leases to forest companies who work to approved 25 year plans of operations with 5 year commitments covering all forest operations from watershed management to harvesting and regeneration. The forest companies own 20% of the forest which has to be managed with a sustained yield concept. The remaining 32% of forest is owned by 35,000 individuals. Private owners have formed 7 Wood Marketing Boards which receive advice and technical assistance from the Provincial Forest Service.

A new forest organisation complex, the Hugh John Flemming Centre, which will open this year is the result of $85 M investment from several government and University sources. A joint province Maritime Forest Ranger School opened on the site in 1986. The Canadian Forestry Service for the Maritimes will be based here, the New Brunswick Department of Natural Resources and Energy, the University Forest Research, Forest
AROUND THE WORLD

Soils, Plant Testing and Forest Engineering and also The Maritime Forest School will all be at this centre at Fredericton. Various non-government forest associations will also be accommodated on the site.

Prince Edward Island

The Island has chosen Red Oak (Quercus rubra) as its provincial tree. Although well represented initially on some of the better land, much of this was cleared for agriculture. Some of this is now being colonised by less desirable tree species. Species which are mentioned include black spruce, red pine, white pine, eastern larch and eastern hemlock and introduced Douglas fir and Norway spruce. There is mention of sawmills with an output of 16M board feet of lumber but an inference that there are large quantities of indifferent timber available. Some 120,000 cords of fire wood used would represent $18M worth of fuel oil imports. Wood fuel is also under serious consideration to assist in the Island’s generation of electricity. The planting programme for 1987/88 will use 2.8M trees.

Nova Scotia

Private owners have 75% of the province’s forest. Some 6,000 of the 30,000 individuals have entered into approved forest management schemes during the last 10 years. The provincial forest nursery started production in 1927 and celebrated the planting of its 100 millionth tree in 1987; annual production has now risen to 30M, mainly raised in paper pots in ‘poly houses’ with the trees being fit for planting at an age of six months. Details of the selected tree for the province, Picea rubens suggest it reaching sawlog rotation size in 60 years; the accompanying sketch showing needles, habit and cone appear remarkably similar to those of Pinus contorta.

Newfoundland

Forest harvesting has not been able to keep pace with available timber resulting from fire and insect damage. Spruce Bud Worm is killing trees with a volume of 45M m³ each year. Since 1974 $130 M has been invested in improving the forest resource. A road construction programme has improved access to the forest and allowed greater recovery of timber from recently killed trees and improved the performance of ground based fire fighting. Aerial fire fighting has depended upon the fleet of six ex World War II Cansos planes; these were capable of collecting 3,637 l of water in 15 seconds. A new fleet of four CL 215’s has been commissioned, each capable of collecting 5,346 l of water in 10 seconds. Canada has also sold these specially designed aircraft abroad with 20 going to Spain, 15 to France and 14 to Greece. Severe fires can leave insufficient seed trees for natural regeneration. Direct seeding from helicopters has been implemented on 315 ha of crown land and 508 ha of forest company land. The rate of seed distribution was intended to provide 50,000 viable seeds of Jack pine/ha and 125,000 seeds/ha for the areas intended for black spruce regeneration. The programme of planting has supplied 22M trees over the last 5 years and the production rate is being increased.

CHILE

The October ’87 issue of Chilean Forestry News quotes the volume of sawn timber produced in 1986 as 2,025,967 m³. The 1,597 sawmills and 16,827 employees of forest industry depends upon the success of plantations of the exotic Pinus radiata. Production in 1960 was under 700,000 m³ with 70% of the timber being native species; by 1977, P. radiata had risen to 96% of the raw material. The percentage of material being exported
rose from 10% in 1960 to 50% in 1977; increased local demand had curtailed export percentage to 42.7% in 1986, but during the first nine months of 1987, the export value of timber products was already $4.7 M above the 1986 total. Timber exports are sent to 59 countries, 33% to South East Asia, 31% to Latin America and 26.7% to Europe. The most significant items are bleached and unbleached wood pulp, radiata pine lumber, newsprint and radiata saw logs.

The National Forestry Corporation (CONAF) has responsibilities for areas of desert such as the 1.6M ha of the Tamarugal Plain in the Atacama. Apart from being dry, frosts may be encountered in July and August and layers of salt concentrations are found at depths of 70–100 cm. Species which can cope with these conditions include Prosopis tamarugo, P. alba, P. flexuosa and P. stombulifera. The survival of any vegetation is desirable, but these Prosopis species provide edible seeds for stock and can be a source of firewood. The Chilean State Industrial Development Corporation planted 22,000 ha between 1960 and 1970 using Prosopis at 10m spacing. Forestry and grazing with sheep and goats has been possible on 12,000 ha. Bee keeping for honey and wax production is also being encouraged. Introduced species under trial include Cercidium microphyllum, C. praecox sp. var No. 1279 and 1286, Prosopis sp. var No. 1286 and 1284, also one of the most promising Prosopis pallida. There are some 20 studies being supported by CONAF/UNDP and FAO. Species under test include Eucalyptus, Acacia, Atriplex, Pinus, Cupressus, Koechia and Populus. The Eucalypts used in dry conditions include E. cladocalyx, E. camaldulensis and E. sideroxylon.

Animal conservation in mountainous regions has raised the population of vicuña at Parinocota from 2,176 in 1976 to 20,229 in 1986. Chile is now allowed to export cloth from the wool of vicuña provided that it is sheared from living animals.

FIJI

The December, 1987 issue of ‘Lookout’, the internal journal of the Fiji Pine Commission, gives the figures for the 1987 fire season, the worst season since pine development started some 25 years ago. Some 473 fires, over half of which were attributed to arson, starting within plantations, burnt 12,685 ha, 27% of the Commission’s Estate. A legal notice, signed by the Minister of Forests, Ratu Sir Josaia Tavaqia KBE, makes it an offence to be in the forest designated area. Conviction for arson carries the penalty of a $1,000 fine and, or two years in jail. The season was dry enough for the normally fire resistant bands of native forest to ignite. It will be possible to recover some sawlogs from a selection of the older stands and some lightly burnt areas may recover. However, the charring on potential logs for chipping will render them unsuitable for the Japanese market. The replanting of the devastated areas, if undertaken, could take five years. Help to assess the future of the forests is being funded by FAO and UNDP in conjunction with work on the Tropical Forestry Action Plan. Further serious fire seasons would destroy the Commission’s prospects of providing a sustained supply of raw material for the young forest industry and the livelihoods of all those involved.

MALAYSIA:

Sabah

The July 1987 issue of Klinkii, the journal of the Forestry Society of the University of Technology, Papua New Guinea, has the following details on Sabah by That Chim Liew.

The area of forest reserve is 3.35 M ha, some 46% of Sabah’s landmass. In 1978, the Director General of the Forest Department warned that the rate of forest depletion was
364,000 ha annually. The yield from the natural forest can range from 8 m$^3$ to 100 m$^3$/ha. It is considered that forest plantations could produce a conservative figure of 25 m$^3$/ha annually.

Large scale forest plantations have been developed since 1973 to provide an area of 43,000 ha by 1984. The three major enterprises are:

**Sabah Softwoods Sdn Bhd**, joint venture between the Sabah Foundation and North Borneo Timbers Berhad. By December 1983, 9,709 ha of *Eucalyptus degulpta* had been established, a total of 25,000 ha by July '84 with a target of 60,000 ha by 1995/99. Each of the main plantation species, *Pinus caribaea*, *Eucalyptus degulpta* and *Acacia mangium* has run into problems, encouraging the use of other species.

**Sabah Forest Development Authority (SAFODA)**, constituted in 1976 to plant 23,000 ha of wasteland over a 40 year period, had planted 16,580 ha by July '84; the main species being *Acacia mangium*.

**Sabah Forest Industries Sdn Bhd** had established 15,214 ha by December '83 towards a target of 1,000,000 ha. The largest area (6,579 ha) was planted with *Paraserianthes falcataria* (Syn. *Albizia falcataria*). Other species used include *Gmelina arborea* (4,267 ha), *Acacia mangium* (1,541 ha) and *Pinus caribaea* (1,015 ha) with further species over another 1,810 ha. The respective rotations for the four species mentioned above are 8 (for pulp and paper markets), 12–15, 12–15 where m.a.i. is 30 m$^3$/ha but where the *Acacia* is planted into grass, the lower m.a.i. of 22 m$^3$/ha extends the rotation from 14–19 years, with the pine there will be an incentive to reach saw log size (ed. suggestion of 22–25 years). *Eucalyptus degulpta* is planned on a 20 year rotation.

Some 170 species have been tried as potential plantation trees, apart from those already mentioned two of the Araucarias show promise, *A. cunninghamii* and *A. hunsteinii*.

In addition to the three organisations mentioned, other mainly private operations are expected to provide a further 100,000 ha of plantations by 2000. Timber production from 530,000 ha at a conservative 11 M m$^3$ a year could satisfy all existing industries and leave scope for 3 M m$^3$ for expansion or export. Improvement in the genetical quality of tree used could offer a realistic volume increase of 20–30% with scope for considerable extra revenue from the improved market value of the timber being produced. An FAO/UNDP tree breeding scheme shows promise of an improvement in the offspring of *Gmelina arborea* from the current 15% desirable to 70% desirable. The recovery of sawn timber from *Acacia mangium* was only 40.4% with 93% of the knots being unsound, consequent upon soft pith; early and regular pruning could improve the recovery figures.

One of the benefits which is anticipated from the expanding plantation programme is that as regular supplies of raw material become available to satisfy those demands currently being met from the natural forest, the rate of erosion of the forest resource can be decreased.

**MEXICO**

Mexico is located on the North American Continent, the tropic of cancer almost equally divides the country in half. There are two main mountain ranges one running essentially north-south and one east-west. These factors are responsible, to a great degree, for the diversity of climate, soil and ecosystems. The country has several types of arid, temperate and tropical vegetation, with around 29 M ha of temperate forest and 15 M ha of tropical forest. This diversity in vegetation is reflected in the great number of timber
Fig. 1 AREAS OF MEXICO COVERED WITH FORESTS.
species available, not all of them commercially attractive. A conservative estimate made a few years ago, assessed this at 750 species (there are nearly 50 species of pine and over 300 species of oak, most of them scrubby). In 1986 according to the official government figures the total production was almost 9 M m$^3$. It is estimated that about an equal amount was cut for firewood, fenceposts, and other rural uses not detected in the official statistics. Pine made up 82% of the recorded production. The primary forest industry is represented by 1197 sawmills, 823 packing box and crate factories, 20 preservation treatment plants, 36 plywood mills, 19 particle and fiberboard factories, and 68 enterprises dealing with the production of pulp and paper. Most sawnwood is being used for the erection of concrete shuttering, for boxes and crates, railway sleepers and furniture. Only a very small proportion is being used for permanent wood structures. The population of the country has been estimated at about 75 M people with an annual growth of 2.1%.

**Research Institutions**

Forest products research was initiated around 1950 when the Instituto Nacional de Investigaciones forestales, was created within the subministry of forestry. This institution has seen many changes over the years. Most research facilities were recently moved from the capital to the town of San Martinito, Puebla, about 80 km to the east of Mexico City. This organization has worked on timber drying, especially in conventional kilns. The section of wood anatomy has the largest wood collection in the country. Other aspects studied include pressure treatment, natural durability, machinability of mainly tropical species and strength properties of clear wood based on small specimens.

In 1976 the Instituto de Madera, Celulosa y Papel was created as part of the University of Guadalajara. This institution has research on pulp and paper. They have a teaching programme at four levels, technical, bachelor, masters and doctorate. The main research area deals with wood chemistry, pulping process, bleaching of pulps, bioengineering and also provides technical assistance to industry preparing feasibility studies for potential pulp and paper operations. There are fifteen laboratories including a pilot plant for the manufacture of pulp and paper, with 19 researchers and their support staff.

In the Instituto de Biologia of the Universidad Nacional Autonoma de Mexico, the Laboratorio de Ciencia y Tecnologia de la Madera — LACITEMA — was created in 1967 and remained there until 1976 when it was moved to Xalapa, Veracruz when the Instituto Nacional de Investigaciones sobre Recursos Bioticos was founded. Research on the anatomy and on the fungal degradation of wood is continuing at the Instituto de Biologia.

LACITEMA is housed in a converted coffee warehouse where most of the laboratories and offices are located on an area of 1400 m$^2$. In addition a pole type building was erected for the carpentry shop, with a surface of 486 m$^2$. The technical staff comprises, ten researchers and five technicians with the following disciplines represented: Wood Technology, Biology, Architecture, Civil Engineering, Chemical Engineering and Industrial Design. It is LACITEMA's mission to contribute to the economic and social development of the country by promoting the rational and sustained utilization of its forest resources through research, training and technical assistance in the area of wood science and technology.

Even though, the laboratory is composed of a relatively small staff and has been in existence for only a few years, has had to operate within a restricted budget yet some significant advances have been accomplished. Besides having created a core of young
and highly motivated researchers much has been learnt about the 750 commercial or potentially commercial species.

Studies have covered wood anatomy, degradation of timber by insects, fungi and climate, both in the laboratory and in the field; assessing the effects of preservation, air and solar drying on the physical and mechanical properties of timber. The results have led to the adoption of several official standards dealing with preservation and grading. Support from local industry and IDRC-Canada helped create grading rules for all species of pine for structural purposes. More than 1500 pieces of lumber from different regions of the country were used in full size tests. The rules, plus the derived strength values have been incorporated into the building code of Mexico city. Complementary to this effort, design aids have been prepared, and short courses for engineers and architects have been given, together with technical assistance to government and private builders of low cost housing. Recently the laboratory has prepared a draft for discussion of a performance standard of panel products for structural purposes. A classification of timber according to eighteen end uses has been prepared and will soon be published. The laboratory sends a bimonthly newsletter to people in industry, and publishes most of its results through its two series of publications “Notas Tecnicas” and “Madera y su Uso”.

LACITEMA will continue to give priority to topics which show promise of increasing the utilisation of lesser known species for structural use. Modest technical investment might then allow more minor species to help alleviate the housing shortage.

Although Forest Products Research in Mexico is a fairly new activity, carried out by few institutions with young personnel, the strong link with local industry and good communications between those carrying out the research and those implementing the findings on the ground shows promise of benefit to the community. (Based upon a report to the CFA by Dr. Ramon Echenique-Manrique, Xalapa, Veracruz, Mexico.)

PERU

The US Agency for International Development has granted $200,000 to the US Nature Conservancy and its Peruvian sister organisation to establish the Yanachaga-Chemillen National Park. The Park will stretch from the Yanachaga Range and water-shed of the Rio Palcaza and high altitude dwarf forest to wet tropical forest. The Park, in Oxapampa province, 40 km east of Lima, is the key to the larger Central Selva Project which is attempting to offer a model for the management of Amazon forests to provide a sustained resource for the native people.
ASSAYING NATURAL CLIMATIC VARIABILITY IN SOME AUSTRALIAN SPECIES WITH FUELWOOD AND AGROFORESTRY POTENTIAL

By T. H. BOOTH and T. JOVANOVIC*

SUMMARY
Data from over 600 sites in Australia were used to determine the bioclimatic profiles of Acacia aulacocarpa, Acacia auriculiformis, Acacia holosericea, Acacia mangium, Casuarina cristata, Casuarina glauca, Grevillea robusta, Melaleuca dealbata and Melaleuca quinquervia. It was concluded that these profiles would be useful when establishing trials outside Australia. They would provide a preliminary indication of climatic requirements and assist the selection of provenances for particular climatic conditions.

Introduction
Actual or potential fuelwood shortages are a serious problem in some 75 countries (Miller et al. 1986). To solve this problem requires the efficient use of both native and introduced tree species.

Australian eucalypts are already grown successfully in many countries (Jacobs 1981). Although there has been some controversy over their use (Shiva and Bandyopadhyay 1983), several authors have concluded that eucalypts can be an appropriate choice, provided careful assessments are made of ecological, economic and social requirements (Poore and Fries 1985; Davidson 1985; Florence 1986). Selecting suitable species and provenances for different environments is an important part of this process.

As well as eucalypts, other Australian tree species have potential for fuelwood and

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agroforestry. Many alternatives are adapted to poor soil conditions and dry climatic environments that typify those in areas most in need. Several species are worth testing (Boland and Turnbull 1981), but information about their environmental requirements is lacking.

Booth (1985) showed how the bioclimatic analysis programme (BIOCLIM) devised by Nix, Busby and Hutchinson could be used to analyse the natural distribution of *Eucalyptus citriodora* Hook. The climatic profile derived from the analysis was then used to indicate locations in Africa which would be climatically suitable for growing *E. citriodora*. As this species had already been widely tested in Africa, it was possible to compare the climatic analysis with actual experience and conclude that it produced useful results.

In this paper we examine the natural climatic variability of some non-eucalypt species. The bioclimatic profiles provide preliminary information on climatic suitability. The climatic data for many locations within each specie’s distribution can assist the selection of provenances for trials outside Australia.

**Methods**

The following species and subspecies, which have potential for fuelwood and agroforestry use, and have not been widely tested outside Australia, were chosen for evaluation;

*Acacia aulacocarpa* A. Cunn. ex Benth.
*Acacia auriculiformis* A. Cunn. ex Benth.
*Acacia holosericea* A. Cunn. ex G. Don.
*Acacia mangium* Wild.
*Casuarina cristata* Miq. subsp. cristata
*Casuarina cristata* Miq. subsp. pauper (F. Muell. ex Miq.) L. Johnson.
*Casuarina glauca* Sieber ex Sprengel.
*Grevillea robusta* A. Cunn. ex R. Br.
*Melaleuca dealbata* S. T. Blake.
*Melaleuca quinquenervia* (Cav.) S. T. Blake.

The analysis followed a similar procedure to that described by Booth (1985). Latitude, longitude and elevation data were collected for sites within the natural distribution of each species. Booth (1985) had been able to take advantage of the computer database EUCALIST (Chippendale and Wolf 1984) when analysing *E. citriodora*. In the study described here, data were gathered mainly from written records held at the CSIRO Division of Forest Research. Further useful data were obtained from Australian State Herbaria.

Many of the records lacked elevation data. Where necessary these were estimated from 1:100 000 or 1:250 000 scale maps using latitude, longitude and brief locational descriptions as a guide. The number of observations for each species is recorded in Table 1. Figure 1 shows the distribution of the data points for all nine species.

The BIOCLIM programme was used to estimate climatic conditions at each of the locations shown in Figure 1. Hutchinson and Bischof (1983) described the type of interpolation methods used by the programme, whilst Nix (1986) and Busby (1986) described applications. The surfaces used by the programme estimate monthly maximum and minimum temperatures with a mean error of 1.3 and 4.1 % respectively. Errors associated with estimates of monthly mean precipitation are generally below 10%. Complete details of the monthly errors for the two continental temperature and the 19 regional precipitation surfaces are available from the authors on request.
Table 1
Climatic profiles based on analysis of natural distribution in Australia.

<table>
<thead>
<tr>
<th>Bioclimatic factors</th>
<th>Acacia aulaco. (85)</th>
<th>Acacia auricul. (62)</th>
<th>Acacia holo-ser. (72)</th>
<th>Acacia mangium (59)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Annual mean temp.</td>
<td>17.3 28.1</td>
<td>25.7 27.9</td>
<td>20.5 28.3</td>
<td>22.9 26.3</td>
</tr>
<tr>
<td>2. Cold. m. min. temp.</td>
<td>3.5 20.6</td>
<td>12.6 20.5</td>
<td>4.5 20.3</td>
<td>12.0 19.9</td>
</tr>
<tr>
<td>3. Hot. m. max. temp.</td>
<td>27.5 38.8</td>
<td>32.3 38.4</td>
<td>29.1 39.6</td>
<td>31.3 33.3</td>
</tr>
<tr>
<td>4. Annual temp. range</td>
<td>12.2 26.4</td>
<td>11.8 25.1</td>
<td>12.1 32.6</td>
<td>12.7 20.5</td>
</tr>
<tr>
<td>5. Wet. q. mean temp.</td>
<td>22.0 31.1</td>
<td>27.0 29.9</td>
<td>23.4 31.4</td>
<td>25.2 27.4</td>
</tr>
<tr>
<td>6. Dry q. mean temp.</td>
<td>12.5 25.7</td>
<td>22.7 25.8</td>
<td>15.7 27.2</td>
<td>20.1 25.4</td>
</tr>
<tr>
<td>7. Annual mean precip.</td>
<td>723 1849</td>
<td>763 1667</td>
<td>302 1670</td>
<td>1156 3659</td>
</tr>
<tr>
<td>8. Wet. m. mean precip.</td>
<td>112 458</td>
<td>185 432</td>
<td>68 417</td>
<td>318 799</td>
</tr>
<tr>
<td>9. Dry m. mean precip.</td>
<td>0 59</td>
<td>4 0</td>
<td>0 21</td>
<td>2 94</td>
</tr>
<tr>
<td>10. Annual precip. range</td>
<td>83 443</td>
<td>184 431</td>
<td>59 411</td>
<td>308 745</td>
</tr>
<tr>
<td>11. Wet. q. mean precip.</td>
<td>319 1191</td>
<td>519 1152</td>
<td>165 1095</td>
<td>810 1947</td>
</tr>
<tr>
<td>12. Dry q. mean precip.</td>
<td>2 210</td>
<td>0 18</td>
<td>2 69</td>
<td>12 303</td>
</tr>
</tbody>
</table>

The BIOCLIM programme was used to determine 36 mean monthly values for daily maximum temperature, daily minimum temperature and total precipitation for every specie's location. From these values we calculated 12 important climatic factors (Table 1). Maximum and minimum values for each factor were determined for each specie. For example, within the 85 locations for *A. aulacocarpa*, the lowest annual mean temperature was 17.3°C at a site seven kilometres east of Boonah (28°0'S 152°36'E, 440 m) and the highest was 28.1°C at a location in Keep River National Park (15°50'S 129°4'E, 60 m). The ranges for other factors are similarly summarised in Table 1. Data for all factors at all sites are available from the authors on request.

The climatic profiles shown in Table 1 were used to evaluate conditions at meteorological stations in Africa, using the method described by Booth (1985). Data
Table 1 (contd.)

<table>
<thead>
<tr>
<th></th>
<th>Grevillea robusta</th>
<th>Melaleuca dealbata</th>
<th>Melaleuca quinquin.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(25)</td>
<td>(59)</td>
<td>(88)</td>
</tr>
<tr>
<td>1. Annual mean temp.</td>
<td>Min. 14.7 Max. 20.1</td>
<td>Min. 20.9 Max. 27.8</td>
<td>Min. 17.1 Max. 26.5</td>
</tr>
<tr>
<td>2. Cold. m. min. temp.</td>
<td>Min. 2.3 Max. 8.2</td>
<td>Min. 10.3 Max. 20.6</td>
<td>Min. 4.3 Max. 20.4</td>
</tr>
<tr>
<td>3. Hot. m. max. temp.</td>
<td>Min. 24.8 Max. 30.5</td>
<td>Min. 28.4 Max. 37.1</td>
<td>Min. 26.1 Max. 33.7</td>
</tr>
<tr>
<td>4. Annual temp. range</td>
<td>Min. 20.5 Max. 26.4</td>
<td>Min. 11.8 Max. 25.2</td>
<td>Min. 11.9 Max. 25.4</td>
</tr>
<tr>
<td>5. Wet. q. mean temp.</td>
<td>Min. 19.1 Max. 24.2</td>
<td>Min. 24.2 Max. 29.4</td>
<td>Min. 15.2 Max. 27.5</td>
</tr>
<tr>
<td>6. Dry q. mean temp.</td>
<td>Min. 10.1 Max. 16.0</td>
<td>Min. 17.1 Max. 25.7</td>
<td>Min. 13.8 Max. 25.6</td>
</tr>
<tr>
<td>7. Annual mean precip.</td>
<td>Min. 720 Max. 1719</td>
<td>Min. 693 Max. 2250</td>
<td>Min. 837 Max. 3438</td>
</tr>
<tr>
<td>8. Wet m. mean precip.</td>
<td>Min. 109 Max. 255</td>
<td>Min. 180 Max. 476</td>
<td>Min. 117 Max. 672</td>
</tr>
<tr>
<td>9. Dry m. mean precip.</td>
<td>Min. 30 Max. 57</td>
<td>Min. 0 Max. 60</td>
<td>Min. 2 Max. 86</td>
</tr>
<tr>
<td>10. Annual precip. range</td>
<td>Min. 75 Max. 198</td>
<td>Min. 161 Max. 454</td>
<td>Min. 54 Max. 586</td>
</tr>
<tr>
<td>11. Wet q. mean precip.</td>
<td>Min. 291 Max. 726</td>
<td>Min. 479 Max. 1405</td>
<td>Min. 336 Max. 1900</td>
</tr>
<tr>
<td>12. Dry q. mean precip.</td>
<td>Min. 109 Max. 215</td>
<td>Min. 4 Max. 194</td>
<td>Min. 9 Max. 260</td>
</tr>
</tbody>
</table>

Cold. = coldest, Hot. = hottest, m. = month, q. = quarter, Wet. = wettest, Dry = driest, temp = air temperature (°C), precip. = precipitation (mm).

Numbers in brackets are number of locations used to produce climatic profile.

were available for 617 African locations from the GLOCLIMEANMTH database prepared by Nix, McMahon and Hutchinson (McMahon 1986). The 12 factors listed in Table 1 were calculated for each location. For each specie and each factor a computer programme tested whether the climatic conditions at each location fell within the ranges indicated in Table 1. If a location satisfied all 12 factors for a particular specie it was rated as a class 1 site.

Factors 1, 2, 7 and 12 were known to be important in agricultural studies (H. A. Nix pers. comm.) and were significant in the study of *Eucalyptus citriodora* study (Booth 1985). They represent average temperature and rainfall conditions, along with the stress of cold and drought. If a location failed to satisfy all 12 factors, but had at least these four, it was rated as a class 2 site. Figures 2 and 3 show the location of class 1 and 2 sites in Africa for two of the species tested. These maps were plotted using the MAPROJ programme (Hutchinson 1981). (Maps for the other species are available on request).

**Discussion**

This analysis shows that the method demonstrated by Booth (1985) can be applied to comparatively lesser known species. For all but one of the species analysed it was possible to obtain distribution information for at least 50 sites.

The one exception is *Grevillea robusta* which has a limited geographic distribution. Although only 25 records were available for this specie the climatic variation was greater than expected. The profile shown in Table 1 exceeded the range of natural conditions estimated by Boland *et al.* (1984). They gave mean maximum temperature of the hottest month as ‘about 28–30°C’, mean minimum of the coldest month as ‘5–6°C’ and mean annual rainfall as ‘1000–1500 mm’. The profile shown in Table 1 is similar in some respects to the range of suitable conditions at worldwide plantation sites estimated by Webb *et al.* (1984) who proposed a suitable mean annual temperature range of 13–21°C.
(c.f. 14.7–20.1°C in Table 1) and a mean annual rainfall of 700–1200 mm (c.f. 730–1719 mm in Table 1). These comparisons suggest that the quantitative analysis described here may assist a preliminary analysis of climatic requirements.

Further encouraging evidence for the usefulness of the analysis comes from the two species mapped in Figures 2 and 3. These are the only other species analysed here which
were assessed by Webb et al. (1984). Their estimates included the following requirements;

<table>
<thead>
<tr>
<th></th>
<th>Acacia mangium</th>
<th>Casuarina glauca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual mean temperature (°C)</td>
<td>18–28</td>
<td>18–24</td>
</tr>
<tr>
<td>Hottest month max. temp. (°C)</td>
<td>30–32</td>
<td>20–30</td>
</tr>
<tr>
<td>Coldest month min. temp. (°C)</td>
<td>13–22</td>
<td>10–20</td>
</tr>
<tr>
<td>Annual mean precipitation (mm)</td>
<td>1000–2100</td>
<td>900–1150</td>
</tr>
</tbody>
</table>

The estimates for *A. mangium* are remarkably similar to the ranges in Table 1, especially considering that *A. mangium*’s natural distribution extends outside Australia into Papua New Guinea and Maluku (Molucca Islands). The ranges for *C. glauca* also show considerable overlap.

The lack of information from trials makes it difficult to assess the accuracy with which Figures 2 and 3 indicate climatically suitable areas. Booth (1985) evaluated a similar map for *E. citriodora* using data summarised from many trials. There are few reports of *A. mangium* trials in Africa, though Kessy (in press) has reported good growth at a coastal site in Tanzania. Successful *C. glauca* trials have been reported not only in South Africa (Fig. 3), but also in Kenya, Malawi, Egypt and Tunisia (Charfi 1975: National Research Council 1984).

The analysis of natural distribution used to produce Figures 2 and 3 can provide only a first approximation of climatic needs. It is well known that species are highly variable in their abilities to adapt to climates outside their natural distribution (Streets 1962; Jacobs 1981). Fortunately, the climatic analysis methods outlined here can be extended to utilise information from trials. This information can be used to improve knowledge of a species climatic requirements.

Booth (1985) outlined a proposed experiment to analyse the natural distribution of twelve eucalypt species, to evaluate their performance in trials in Africa and use this information to develop improved climatic profiles. This work has been successfully completed and will be reported elsewhere. Similar methods could be used to improve the knowledge of the species analysed here as results from trials become available.
In the meantime, the profiles and maps presented here, as well as the additional information available on request, can be used to assist selecting suitable sites for trials. Caution should be taken in assessing the results. In particular, low rainfall recordings may not always adequately represent the soil water conditions. Although several of the species listed here are found in arid and semi-arid environments, they occur in riverine locations or situations experiencing water run-on. As information is gathered from trials it is likely that some of the lower estimates of water requirements will be raised.

Although the interpretation of results from low rainfall sites should be treated with care, such sites would be worth visiting if a range of provenances was being selected. It would then be possible to determine if the trees were favoured by micro-environment or if they were adapted to low rainfall. The data describing climatic conditions at individual sites could similarly assist provenance selection from relatively cool or hot environments.

Climate is but one important factor to be considered when choosing species and provenances for trials. This work suggests quantitative climatic analysis can assist directly in the selection of some lesser-known Australian species.

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A MULTIPLE-SOURCE APPROACH TO SELECTION IN HONDURAS CARIBBEAN PINE SEED ORCHARD ESTABLISHMENT FOR THE NORTHERN TERRITORY OF AUSTRALIA

By M. W. Haines¹, D. G. Nikles and T. Spidy²

SUMMARY

Environmental constraints for Honduras Caribbean Pine (Pinus caribaea Mor. var. hondurensis Barr. and Golf) seed production in the Northern Territory of Australia have prompted a cooperative arrangement with the Department of Forestry in Queensland whereby future supplies of genetically improved seed will be produced from a special clonal seed orchard in that State.

The initial orchard establishment phase includes clones from plus phenotypes selected in both the Northern Territory and Queensland. These are predominantly of Mountain Pine Ridge, Belize origin, but a number of trees derived from coastal lowland provenances are also deliberately represented.

The potential benefit from using this broadly based seed producing population will depend on adequate and synchronous flowering across the provenances represented.

RÉSUMÉ

Des contraintes environnementaux pour la production de graines du pin des Caraïbes Hondurien (Pinus caribaea Mor. var. hondurensis Barr. et Golf) dans le territoire du Nord de l'Australie ont incité un arrangement coopératif avec la Direction des Forêts en Queensland par lequel la provision future de graines améliorées génétiquement sera produites par un verger à graines clonal spécial dans cet état.

La phase initiale d'établissement du verger comprend des clones de phénotypes plus choisis et en territoire du Nord et en Queensland. Ceux-ci sont d'une manière prédominante de la provenance Mountain Pine Ridge, Belize, mais un certain nombre d'arbres dérivés de provenances de la plaine littorale sont représentés exprès.

L'avantage potentiel de l'utilisation de cette population productrice de graines à base large dépendra de la fleuraison suffisante et synchrone en travers des provenances représentées.

RESUMEN

Limitaciones climáticas para la producción de semilla de Pino caribe hondureño (Pinus caribaea Mor. var. hondurensis Barr. y Golf.) en el Territorio del Norte de Australia, han conducido a un acuerdo cooperativo con el Departamento Forestal en Queensland, mediante el cuál el abastecimiento futuro de semilla genéticamente mejorada se obtendrá de un huerto semillero por clones especial, establecido en este último estado.

La fase inicial del establecimiento del huerto incluye clones de fenotipos superiores seleccionados tanto en el Territorio del Norte como en Queensland. Estos son en su mayoría de la procedencia Mountain Pine Ridge, Belice, sin embargo,

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están también deliberadamente representados cierto número de árboles de procedencias costeras de tierras bajas.
El beneficio potencial del uso de esta población productora de semillas de base genética tan amplia, dependerá de una adecuada y simultánea floración en las procedencias representadas.

Introduction
Low yields of viable seed from Pinus caribaea Mor. var. hondurensis Barr. et. Golf. (Honduras Caribbean Pine) plantations on Melville Island (Brigden and Haines, 1984; Haines and Robertson, 1986) have necessitated special co-operative arrangements for the establishment of an initial clonal seed orchard for the Northern Territory (Haines et al., 1986).

Development of a 2 hectare site at Byfield in Queensland is being undertaken in two stages. A broadly based seed producing population was considered appropriate to maximise the potential benefit from this co-operative strategy.

The Selection Base
Small trial plantings of Honduras Caribbean Pine were commenced in the Northern Territory (N.T.) in 1965/66, and this species has been used almost exclusively for operational plantings since 1976/77 (Haines, 1983). Seed obtained from Queensland for this modest programme is of Mountain Pine Ridge (M.P.R.), Belize origin, reflecting the prominence of this provenance in routine plantation establishment and tree improvement studies with Honduras Caribbean Pine in that State. Concurrent provenance testing has provided a small, but significant addition to this resource base.

Provenance research has gained impetus through the extensive international trials co-ordinated by the Commonwealth Forestry Institute (Kemp, 1973; Greaves, 1980) and this has enabled a much broader evaluation of performance. The high productivity in these trials of stands derived from Queensland, Byfield Clone Bank 127B seed source (improved M.P.R. provenance, included for comparison) confirms the gains realised through the Queensland tree breeding programme, but unimproved sources for several other provenances have also performed well (Gibson et al., 1983a).

Studies in Queensland have demonstrated the superior stem straightness and greater windfirmness of the Central American coastal lowland provenances, and thus the tree breeding potential of the more productive of these sources for plantation establishment, particularly in areas susceptible to wind damage (Qld. Dept. For., 1981; Nikles et al., 1983; Eisemann et al., 1984).

In the absence of substantial growth differences between provenances on Melville Island almost 10 years after planting (Tozer and Haines, 1984) orchard composition has been based on a multiple-source approach with respect to both provenance representation and regions for phenotypic selection.

Selection Criteria
The aim in determining the clonal composition for the first orchard establishment stage has been to use selected phenotypes from Melville Island (a selection-to-site approach) as the main component, and to supplement this number with some of the outstanding selections from the Queensland tree breeding programme.

With the predominantly M.P.R. selection base in both the N.T. and Queensland, two thirds of the final composition are from this provenance, including some second generation selections which will hopefully convey the advantage of more advanced breeding. The remaining orchard component came from outstanding individual
phenotypes in stands derived from coastal lowland provenances of the Central American mainland and the insular source of Guanaja Island. Sources represented in the first orchard stage are given in the following table.

Table 1
Sources of Honduras Caribbean Pine clonal material for stage 1 of the Northern Territory Orchard.

<table>
<thead>
<tr>
<th>Origin and Improvement Status</th>
<th>Melv. Is. (N.T.)</th>
<th>Byfield (QLD.)</th>
<th>Cardwell (QLD.)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>* 2 gen. control pollinated selections (ex MPR)</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>* 2 gen. open-pollinated selections (ex MPR)</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>* 1st. gen. selections</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>— MPR origin</td>
<td>12</td>
<td>1</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>— Coastal Lowland or insular origin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brus Lagoon</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Silma Sia</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Karawala</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Melinda</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Alamicamba</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Guanaja</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>* Origin uncertain</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>23</strong></td>
<td><strong>7</strong></td>
<td><strong>6</strong></td>
<td><strong>36</strong></td>
</tr>
</tbody>
</table>

Table 2
Honduras Caribbean Pine plantings on Melville Island that may contribute additional candidates for stage 2 selection.

<table>
<thead>
<tr>
<th>Type of planting</th>
<th>Year planted</th>
<th>Description of the resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progeny Trials</td>
<td>1979/80</td>
<td>A total of around 120 families, mainly of M.P.R. origin. This includes over 100 families not previously evaluated in the N.T.; approx. 40 from Queensland and the remainder from New Caledonia, Fiji, D.R. of the Congo and Central America.</td>
</tr>
<tr>
<td>Progeny Trials</td>
<td>1981/82</td>
<td>A total of 84 families, all of M.P.R. origin: includes approx. 40 additional families not yet evaluated in the N.T.</td>
</tr>
<tr>
<td>Family x Provenance</td>
<td>1981/82</td>
<td>Embraces 90 families from a total of 9 Central American provenances, 40 of the families are from 5 coastal lowland sources.</td>
</tr>
<tr>
<td>Routine &amp; Experimental</td>
<td>1972/73 to 1979/80</td>
<td>Approx. 600 hectares, mostly of M.P.R. origin.</td>
</tr>
</tbody>
</table>

The composition of stage 2 will depend on the outcome of an assessment of this genetic resource.
Individual phenotypes were selected in the N.T. and Queensland after the assessment and screening of a considerable number of candidate trees in relation to vigour, stem form and branching characteristics. Considerable emphasis was placed on vigour and, in general, selections embrace those trees with highest assessment scores, whether from an improved genetic source or not and irrespective of provenance or selection locality.

The notable exception to this strategy was the elimination of some second generation plus trees where common ancestry, due to the prominence of some outstanding individual parents in the Queensland breeding programme, would have given an unacceptable level of relatedness among orchard clones.

Regional Contribution

The regional derivation of clones represented in the orchard is indicated in Figure 1.

Co-operation in the exchange of genetic material between breeding programmes has been advocated as a means of initiating or improving breeding populations (Nikles, 1984). The contribution of material from Queensland in this instance is a practical expression of that philosophy and is indicative of the general co-operation that exists between countries/organisations involved in the improvement of Caribbean Pine.

Provenance Representation

Figure 2 indicates the Central American sources from which the orchard selections originate.

Benefits from this orchard composition will only accrue if adequate and synchronous flowering occurs across the provenances represented. Clear differences in cone production between upland and lowland sources are evident in the international provenance trials (Gibson et al., 1983b) where the precocious habit of the upland
Figure 2. Provenances of Honduras Caribbean Pine represented in stage 1 of the Northern Territory Orchard.

provenances (including M.P.R.) contrasts with the generally shy early flowering in stands of lowland origin. Although it appears that this difference may diminish as stand age increases, the situation in the orchard will need to be closely monitored. Preliminary observations in Queensland indicate that the upland and coastal provenances flower at the same time.

Orchard Establishment

Scions from 39 candidate trees in the N.T. were established in a clone bank at Byfield in 1984 to allow observation of stock/scion compatibility and the proliferation of suitable grafting material. Some 23 clones of outstanding merit were selected for orchard inclusion. Adequate clonal material was already available for the further supplement of 13 selections from the Queensland breeding programme.

Field grafting for the 1 hectare initial stage was carried out in August/September, 1985 on to stock double planted at 6 × 6 metre spacing in April 1984. Recent observation showed that at least one successful graft has been achieved for 96% of the 275 stations embraced in the orchard layout.

Future Development

It is expected that stage 1 will be progressively culled to leave around 96 stems per hectare comprising the 12 best clones by about age 12. The testing of open-pollinated progeny from the orchard ramets will be commenced on Melville Island as soon as adequate seed is available, and the early results from these trials will help to determine the families to be retained.

Establishment of the remaining 1 hectare (stage 2) will be delayed until 1988, allowing time for evaluation or screening of the additional resources on Melville Island outlined in table 2.
REFERENCES


A CO-OPERATIVE PROJECT TO FACILITATE ORCHARD PRODUCTION OF HONDURAS CARIBBEAN PINE SEED FOR THE TOP END OF THE NORTHERN TERRITORY OF AUSTRALIA

By M. W. Haines¹, D. G. Nikles and T. Spidy²

SUMMARY

Plantations of Honduras Caribbean Pine (Pinus caribaea Mor. var. hondurensis Barr. and Golf) on Melville Island in the Northern Territory of Australia display good vegetative growth, but environmental constraints on seed production preclude genetic improvement through a locally based clonal seed orchard.

Co-operative arrangements with the Department of Forestry in Queensland have facilitated orchard establishment in a favourable environment in that State. The agreement allows the Northern Territory to specify the clonal composition of the orchard, and thus to utilise selected superior phenotypes from local stands.

Similar strategies may be relevant to other tropical countries where climatic conditions restrict seed production.

RESUME

Les plantations du pin des Caraibes Hondurien (Pinus caribaea Mor. var. hondurensis Barr. et Golf) sur Melville Island dans le territoire du Nord de l'Australie montrent un bon accroissement végétatif, mais des contraintes environnementales sur la production de graines empêchent l'amélioration génétique par moyen d'un verger à graines clonal établi dans la région.

Des arrangements coopératifs avec la Direction des Forêts en Queensland ont facilité l'établissement d'un verger dans un milieu propice dans cet état. L'arrangement permet au territoire du Nord de préciser la composition clonale du verger, et donc d'utiliser des phénotypes supérieurs choisis parmi les peuplements locaux.

Des stratégies semblables peuvent être applicables à d'autres pays tropicaux où les conditions climatiques limitent la production de graines.

RESUMEN

Las plantaciones de Pino caribe hondureño (Pinus caribaea Mor. var. hondurensis Barr. y Golf.) muestran buen crecimiento vegetativo en la Isla de Melville en el Territorio del Norte, Australia, sin embargo, las limitaciones ambientales para la producción de semilla, impiden el mejoramiento a través de huertos semilleros locales.

Mediante un acuerdo cooperativo con el Departamento Forestal en Queensland, se ha facilitado el establecimiento de huertos en sitios favorables en este estado. El acuerdo le permite al Territorio del Norte especificar la composición clonal del huerto y así utilizar fenotipos superiores seleccionados en rodales locales.

Estrategias similares podrían ser relevantes para otros países tropicales, donde las condiciones climáticas limiten la producción de semillas.

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Background

Pinus caribaea Mor. var. hondurensis Barr. et Golf. (Honduras Caribbean Pine) is an important exotic plantation species, and is now widely planted throughout the tropics. By 1981, more than 50 tropical countries were participating in international trials of this species (Greaves, 1981).

Environmental factors have strongly influenced the flowering and seed production of Honduras Caribbean Pine in exotic plantations and these factors may prevent, or substantially reduce, the yield of viable seed in more equatorial lowland climates (Gallegos, 1981).

Local studies (Brigden and Haines, 1984; Haines and Robertson, 1986) indicate that the Northern Territory (N.T.) plantations conform to this pattern, and follow the predicted performance of this species in relation to mean monthly day length and temperature (Slee, 1977). While selection to develop a unique N.T. landrace may ultimately improve local seed production (Haines, 1983), this may be at the expense of other important economic traits.

The establishment of a conventional clonal seed orchard was seen as the most positive strategy for early and sustained tree improvement, but necessitated location of the orchard in a favourable environment outside the Northern Territory. This has been facilitated by a co-operative arrangement with the Department of Forestry in Queensland.

Although there are precedents for this type of approach in other countries, it is probably unique with respect to tree breeding in Australia and as a seed production strategy for this species in the tropics.

Co-operative Framework

The project represents a business arrangement in which fees payable by the Conservation Commission of the Northern Territory (C.C.N.T.) will enable the Queensland Department of Forestry (Q.D.F.) to recover the cost of services rendered with respect to orchard establishment and maintenance. The main elements of the agreement are:

Q.D.F. to provide a suitable site of around 2 hectares at Byfield for orchard establishment and management to normal Queensland prescriptions.
C.C.N.T. to specify the clonal composition of the orchard and supply scion material from N.T. selections.
Q.D.F. to supply scions from selected Queensland source material.
An establishment fee of $5,000 is applicable in the first year of the project (1985).
A management fee of $3,000 to be paid in each subsequent year (with CPI escalation at 3 year intervals) until termination of the agreement.
Q.D.F. will arrange cone collection and extraction of seed, subject to a negotiated fee.
C.C.N.T. will have first rights to all seed produced.
Trees in the orchard will remain the property of the Q.D.F., and no liability is accepted for loss or damage.
The contract period will be 20 years, subject to the right of the C.C.N.T. to cancel the agreement at any time.

Location and Features of the Orchard

The orchard occupies a 2 hectare site in the Valentine area of the Byfield State Forest. Honduras Caribbean Pine seed production in this locality has been good, and recent
flowering in a new Q.D.F. orchard nearby suggests that around 10 kilos of seed per hectare will be harvested in 1987 (7 years from grafting). Annual production is expected to peak at around 30–35 kilos per hectare.

The first establishment stage embraces clones from a composite selection of 36 plus phenotypes; 23 from Melville Island, N.T. (including some open-pollinated progeny from Queensland families) and the remainder from Byfield and Cardwell in Queensland, (Haines et al., 1986). The selected phenotypes originate predominantly from the Mountain Pine Ridge (MPR) source in Belize, reflecting the wide use of this provenance for routine plantation establishment and the consequent past emphasis on this source in tree breeding.

The inclusion of a number of second generation selections takes advantage of the improvement already realised in the Queensland programme (Nikles et al., 1981). There is, however, a significant component of trees representing the potentially valuable coastal lowland provenances of Central America (Nikles, 1984; Eisemann et al., 1984) and their introduction provides a much more diverse total seed producing population (Haines et al., 1986).

The Establishment Phase

Grafting for the 1 hectare initial stage was carried out in August/September 1985. Establishment of the remaining 1 hectare will be delayed until 1988. This will allow time for the evaluation of further young progeny trials on Melville Island that may contribute new candidates for inclusion in the orchard.

Discussion

Genotype-environment interactions in Honduras Caribbean Pine at the provenance and family levels are shown to be relatively low over the climatic range represented by the major plantation centres in Queensland (Eisemann and Nikles, 1984).

However, individual selection-to-site is likely to become increasingly important as the range of environmental conditions is extended. This may be especially so at the extremes of the environmental range, but the poor flowering and seed production that is characteristic of tree development in such areas also restricts or precludes local improvement by a selection-to-site approach (unless orchards can be established elsewhere).

It is anticipated that this constraint for the ‘Top End’ of the Northern Territory will be overcome by recourse to the co-operative arrangements outlined in this paper. The strategy facilitates the supply of seed from superior clones of locally selected phenotypes and may provide a model for other tropical countries where climatic conditions impose similar limitations on seed production.

REFERENCES


INSTITUTIONAL ARRANGEMENTS AND RESEARCH STRATEGY FOR AGROFORESTRY IN VICTORIA, AUSTRALIA AND ZIMBABWE

By H. T. L. Stewart*

SUMMARY

Agroforestry research is being implemented in Victoria, Australia, and in Zimbabwe, to develop technologies for improving the production of farming systems at a sustained level. In both countries, similar institutional arrangements and research strategies have been used in setting up the programmes. A two-level management structure has been adopted, the top level being a steering committee responsible for policy and management of the programme, the second level a research committee that designs and implements specific projects. These are interdepartmental committees, though for the long-term, the preference is for an agroforestry research unit with an institutional focus. The research is a complementary mix of on-station and on-farm experiments, designed to evaluate agroforestry opportunities identified after description and analysis of existing farming systems. In both Victoria and Zimbabwe, agroforestry is recognised for its high potential to redress some of the serious problems of land degradation, and government has incorporated this type of land use into strategies for conservation of rural resources.

RESUME

Des recherches agrisylvicoles sont en train en Victoria, Australie, et en Zimbabwe pour développer des technologies pour améliorer la production de systèmes agricoles d'une manière soutenue. Dans les deux pays, des dispositions institutionnelles et des stratégies de recherche semblables ont été utilisées dans l'établissement des programmes. Une structure d'amenagement à deux etages a été adoptée, l'étage supérieur étant un comité d'organisation chargé de la politique et l'administration du programme, l'étage inférieur un comité de recherche qui prépare et met en train des projets spécifiques. Ce sont des comités interdépartementaux, bien qu'à long terme on donne la préférence à une unité de recherches agrisylvicoles avec un foyer institutionnel. La recherche est un mélange complémentaire d'expériences au centre de recherches et sur ferme, conçues pour évaluer des possibilités agrisylvicoles identifiées après la description et l'analyse des systèmes agricoles actuels. Et en Victoria et en Zimbabwe, on reconnaît le grand potentiel de l'agrisylviculture pour redresser quelques-uns des problèmes graves de la dégradation de la terre, et le gouvernement a incorporé ce type d'utilisation du sol dans des stratégies de conservation des ressources rurales.

RESUMEN

En Victoria, Australia y en Zimbabwe, se viene implementando investigación agroforestal con el fin de desarrollar tecnologías para el mejoramiento de la producción en sistemas de fincas a un nivel sostenido. Para llevar a cabo los programas, se han utilizado en ambos países arreglos institucionales y estrategias de investigación similares. Se ha adoptado una estructura administrativa de dos niveles,

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donde el comité directivo ocupa el nivel más alto y es el responsable por las políticas y el manejo del programa; el segundo nivel es el comité de investigación, el cual diseña e implementa los proyectos específicos. Estos son comités interdepartamentales, aunque la preferencia para el largo plazo es hacia una unidad de investigación agroforestal con un enfoque institucional. La investigación se realiza bajo una combinación complementaria de experimentos en estaciones experimentales y en fincas de productores, diseñados para evaluar oportunidades agroforestales identificadas después de la descripción y el análisis de los sistemas de producción existentes. Tanto en Victoria como en Zimbabwe, se reconoce a la agroforestería por su alto potencial para corregir algunos de los problemas serios de degradación del suelo y los gobiernos han incorporado este tipo de uso de la tierra en las estrategias para la conservación de los recursos rurales.

Introduction

Agroforestry, the use of the same land for growing agricultural and tree products in combination, is a form of land use that has been practised in many parts of the world. Although agroforestry is intended mainly for the tropics (Nair, 1980), there is also considerable interest in such land use in temperate climates (Reid and Wilson, 1985). Apart from economic benefits, the main interest lies in the potential for agroforestry technologies to redress some of the serious land-use problems in both developed and developing countries.

Despite the voluminous literature on agroforestry, there remains to be done an inordinate amount of research and development if its potential is to be fully realised. The research needs range from straightforward field trials testing the establishment and yield of various agroforestry combinations, to fundamental studies of the biological interactions between crops, trees and animals. These studies are essential in order to evaluate quantitatively the principal potential benefit of agroforestry — that is, diversified and increased production from land on a sustainable basis.

Some of the constraints to overcome in realising the potential of agroforestry are the institutional and disciplinary barriers that affect such aspects of land development as staff training, research, extension and allocation of funds (ICRAF, 1983). Experience shows that unless these barriers are overcome, it is not possible to plan effectively and develop a programme of integrated land-use.

This paper describes the institutional arrangements and research methodology that have been used in setting up agroforestry research programmes in Victoria, Australia and Zimbabwe — these being areas with temperate and tropical climates respectively. The background leading to these programmes is also given. There are many similarities in the approach taken in both countries, and although this work only commenced in 1984, the development of the two programmes is described as models whose principles may have application elsewhere.

Background to the Research Programmes

Victoria, Australia

Victoria has an area of 22.7 million hectares and, with 4.1 million people (1984 census), is the most densely populated State of Australia. Only about 15% of the people live outside the capital and provincial cities. The climate is characterised by cold winter temperatures, erratic and ineffective rainfall in summer, and frequent summer drought. About one-third of the State is forested land, ranging from open-shrubland to tall closed-forest (Specht, 1970). This contrasts to pre-European settlement when shrubland, woodland or forest covered 74% of the State (For. Comm. Vic., 1983).
Most of the present forest is on public land, where the management and utilisation of the resource is tightly controlled. However, on freehold land in the rural sector that comprises some 45,000 commercial farms, the areas of remnant forest are being steadily reduced. In addition, there is a noticeable decline in the numbers of scattered trees that have survived clearing in many agricultural areas: surveys show that in some locations, these trees have been lost at a rate of 1% per year over a recent period of 20–25 years (Kile et al., 1980). The loss of partial tree cover over broad areas of agricultural land, combined with the complete clearing of many upper catchments, are important factors that have led to land degradation and salinity, resulting in declining productivity over significant areas of rural Victoria.

Apart from serious problems of land degradation, many farmers in Victoria are engaged in cropping and animal production enterprises, the profitability of which has generally declined in recent years, because of sharp increases in the costs of finance, fuel and fertilisers, fluctuating commodity prices, marketing problems, and periods of drought. Many single-commodity enterprises have therefore looked at ways of diversifying production, and emphasis has been placed on methods of increasing land productivity. For these reasons, agroforestry has been considered as an alternative to some of the present forms of land use, particularly on larger-scale farms where there is a growing perception that, in the long-term, the only way of ensuring sustained production on sparsely-treed land is to implement a programme of strategic tree establishment within the farming system.

**Zimbabwe**

Zimbabwe is a land-locked country with an area of just over 39 million hectares. The country lies within the tropics and has a climate that features a cold, dry winter, and warm, wet summer. The population of 7.5 million (1982 census) is dominated by two broad cultural groups: the Shona people (77%) and the Ndebele people (17%). Other than a concentration of people in the cities of Harare and Bulawayo, around three-quarters of the population is in rural areas (a contrast to the situation in Victoria).

In rural Zimbabwe, there are two major agricultural systems: a commercial farming system dominated by European farmers, and a communal farming system where around four million people depend on subsistence agriculture. The communal areas cover 42% of the country, yet compared with the commercial farms, the bulk of this land has a much poorer agricultural potential, because of inequitable land distribution in the past (Whitlow, 1985).

The predominant type of farming in the communal areas is an integrated crop and livestock system, with maize and cattle being the major species. The main features of this system are the use of cattle for draught power, the use of crop residues to feed livestock during the winter months, and the use of manure to fertilise arable lands. Production on these areas is being studied through a programme of farming systems research (Avila, 1985), with emphasis on technologies for overcoming the constraints of the farming systems. The main constraints include: lack of food security; shortage of cash; shortage of fuelwood and construction wood; low and erratic rainfall; a predominance of low-quality land for cropping; high cost of materials for fencing; shortage of draught power; and lack of feed, both in quantity and quality, for livestock (Stewart et al., 1986). Thus from the agricultural viewpoint, agroforestry has the potential to stabilise the productivity of farming systems through the introduction of trees which enrich and protect soils on arable and grazing areas, for providing animal fodder, for providing permanent fencing in the form of hedges, and for providing wood and other tree products.
From an afforestation viewpoint, agroforestry may be a means of providing communal farmers with the stimulus to plant trees in the ever-increasing areas of deforested land. One-third of communal lands has severe deficits of wood (Whitsun Found., 1981). Key aspects of the problem were documented in a recent baseline survey of wood usage in communal lands (Du Toit et al., 1984). Amongst these were that wood was used by 99% of the surveyed households for their cooking and heating requirements; sources of fuelwood were generally more than one kilometre from the households; and construction wood, which was generally more difficult to find than fuelwood, was often more than 10 kilometres from the household. A national afforestation programme has started to redress the problem, but a long-term solution will need more than the present emphasis of the establishment of regional nurseries and eucalypt woodlots (Casey and Muir, 1986), especially as fuelwood scarcities alone rarely provide incentive for people to grow trees (Foley and Barnard, 1985). This suggests that the development of appropriate agroforestry technologies, with fuelwood and construction wood as subsidiary benefits of planting trees, may be a means of alleviating the shortage of wood products on some communal areas. Spears (1985) has advocated the use of agroforestry as one way of tackling the fuelwood crisis in developing countries.

Institutional Arrangements

In Victoria and Zimbabwe, organisation of agroforestry research within the relevant institutions was initiated in view of the background described. In both cases, it was recognised that the development of agroforestry requires inputs from many disciplines at the policy, planning and research levels, and that an effective management structure would be needed to link the institutions, who collectively had the necessary skills and resources to plan and implement the programme.

Committees and their Functions

A two-level management structure has been adopted in both instances. The top level is the Agroforestry Steering Committee, an inter-departmental committee that is responsible for policy and management of the programme. The second level is an Agroforestry Research Committee, again an inter-departmental committee, that reports to the Steering Committee and is responsible for design and implementation of the research programme. This arrangement was formalised in Victoria in 1984, and in Zimbabwe in 1987.

Steering Committee

The Steering Committee in Victoria has four senior members who represent research and extension in the government institutions of agriculture and forestry. In Zimbabwe, a larger committee has been formed, with representation from the government institutions of agriculture, forestry, national parks and wildlife, and natural resources, the University of Zimbabwe, and the Scientific Council of Zimbabwe, all at the level of divisional or departmental head.

The general brief of the Steering Committees is to report to and act on behalf of the ministers responsible for agriculture and forestry on: policies for the research and development of agroforestry; co-ordination of research in agroforestry; the provision of resources for agroforestry research; and links with international agencies concerned with agroforestry. Experience shows that meetings should be held at least four times each year, and as frequently as required by business.
Research Committee

The core membership of this committee consists of government research and extension workers from the agriculture and forestry institutions, and university research staff. The Steering Committee nominates all members, as well as a chairperson and executive officer. It is sensible for the chairperson to come from whichever agency (agriculture or forestry) takes the lead role in agroforestry. In Victoria, the chairperson and executive officer (whose main role is financial control) also sit at meetings of the Steering Committee, and so act as a link between the research and policy levels of the management structure. The arrangement in Zimbabwe will allow the Steering Committee to invite these people to its meetings as required.

The Research Committee reports to, and acts on behalf of, the Steering Committee on agroforestry research and extension, with a brief that includes: the drafting of proposals for research priorities in agroforestry; the implementation of specific research projects approved by the Steering Committee; the collection, exchange and review of information on agroforestry research; and the review of proposals for international collaboration in agroforestry. The Research Committee should meet at least four times each year, with meetings shortly before those of the Steering Committee so that up-to-date reports on research progress can be presented to the policy makers.

Long-term Arrangements for Research

Both Victoria and Zimbabwe have appointed an inter-departmental research committee for conducting agroforestry research. The main advantages of this approach are that the committee can be appointed without undue delay by drawing on existing resources within the relevant institutions, and that the strong institutional links required for carrying out agroforestry research are reinforced.

Recognising the long-term nature of agroforestry research, however, there are good reasons for aiming to establish an agroforestry research unit, affiliated with a research institution, as an alternative to an inter-departmental research committee. The main advantages of a research unit are accountability and continuity, since the responsibility for its work can be ascribed to a particular institution, and the continuity of its work is likely to be less affected by changes in key staff.

The major difficulty in establishing a research unit is mobilising sufficient commitment and resources within one institution for research that crosses many disciplines, and has no logical setting within any government agency. Resolution of this would be an obvious role of the Steering Committee.

If a research unit were affiliated with a research institution, it would be necessary to recruit specialist staff, and/or second staff from other departments, in order to assemble the required skills and hence form a viable research group. Experience from Victoria suggests that an equivalent of six persons full-time, including at least two technical support staff, is needed to implement an effective agroforestry research programme. Apart from a full-time team leader, the research-officer equivalents can include some scientists allocating only part of their professional time to agroforestry research. This flexibility makes it easier to build a multi-disciplinary research team, and allows for interchange of staff to meet short-term requirements for specialist skills.

In Victoria, a seven-person inter-departmental research committee (with some staff only allocating part-time to agroforestry) has worked effectively for two years, though if resources permitted, the preference would be to establish a research team with an institutional focus. In Zimbabwe, an inter-departmental research committee has also been established, but efforts are being made to obtain the necessary resources to set up a research unit within the main agricultural research institution.
Research Strategy

The design of an effective agroforestry research programme depends on an understanding of the structure and operation of existing farming enterprises, analysis of the production constraints associated with the current agricultural practices, and identification of the opportunities for introducing improved systems of land use. In Victoria, this information was mainly gathered from the extension and research officers working for the agricultural and forestry institutions in regional centres. Many of these staff have close contact with farming organisations and individual farmers, and many are associated with agricultural research institutes that collectively have comprehensive programmes of research covering the major farming systems in the state.

Development of the research proposals was done in parallel with a large-scale project of rehabilitating degraded agricultural land through a process of whole-farm planning. This involves the analysis of land use on farm units within major catchment areas, with the aim of identifying opportunities for strategic tree planting and improved agricultural practices in order to stabilise the use of rural land on a regional basis. There is considerable scope for agroforestry within this project, mainly in the form of introducing trees into grazing systems for fodder, shelter and land protection.

In Zimbabwe, agroforestry research is being modelled along the lines of the existing programme of farming systems research in communal areas. Within the main farming system (of mixed crops and livestock), three sub-systems of crops, livestock and the household have been delineated as the main functional units for describing and analysing the methods and constraints of production. A useful feature of this approach is that the research and development is not commodity or discipline orientated — instead, alternative technologies for the small farmer are designed and evaluated in the context of the total farm unit. There is a parallel here with the method of whole-farm planning being developed in Victoria, except that in the latter case, a land-use approach rather than a systems approach is being taken. Methods for farming systems research have been described in detail (e.g. Ruthenberg, 1980; Avila, 1985).

There are few guidelines on the extent to which farming systems need to be described and diagnosed before proceeding with the design of research and alternative technologies. The critical aspect of the evaluation phase, from the point of view of obtaining the maximum return from the research effort, is to identify the changes that will have the greatest impact in the least time. The approach can be completely qualitative (e.g. by drawing on the experiences and common sense of the farmers), or it can be quantitative through the use of statistical procedures. In designing the research programmes in both countries, a combination of quantitative (e.g. Garland et al., 1984) and qualitative data was used. Raintree (1986) has described a method for the diagnosis of land management problems and the subsequent design of agroforestry solutions, and some of these principles are being used in developing the programme in Zimbabwe.

Different types of experiments need to be laid down in a programme of agroforestry research. Although these experiments have specific features, some useful principles have been adopted in designing the research in both Victoria and Zimbabwe:

- the initial screening and testing of agroforestry plant species has been done by agricultural and forestry scientists working independently, except that there has been collaboration to decide on the selection criteria that are important in species choice;
- the research programmes consist of on-station plus on-farm experiments;
- the locations of experiments have been chosen to give representative coverage of the range of farming systems and conditions that are the target of the research;
- simple, yet robust, experimental designs have been preferred to more complex designs such as factorial combinations;
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— the choice of treatments is restricted to those technologies that farmers can realistically be expected to adopt under present conditions;

— in order to gain time, particularly with intercropping trials in Zimbabwe, it is planned to have a step-wise, concurrent series of on-station and on-farm experiments, with the latter designed using promising preliminary results gained from the on-station research;

— special subject areas have been placed in the domain of the universities — for example, studies of tree/crop interface effects such as light competition and water relations in Victoria, and studies of soil amelioration by trees in Zimbabwe;

— in deciding on what is agroforestry and what is simply trees on farms, agroforestry is taken to imply significant biological interaction of woody species with crops and/or livestock;

— the tree component of agroforestry systems has been regarded as a crop in the agricultural sense, in an attempt to overcome the common attitude that agricultural and forestry components are discrete entities, with physical and biological barriers that prevent their mutual interaction;

— the role of indigenous species has been given a high priority, especially those plants that have traditionally been valued by the local community;

— extension staff and user-groups have participated in the formulation of the research programme;

— research evaluation will include cost/benefit analyses and modelling of selected on-station and on-farm experiments, so that the research extension of successful agroforestry systems will provide quantitative evidence of increased benefit of adopting the new technology.

Conclusion

Details of specific projects within the research programmes are described for Victoria (Baldwin et al., 1986) and for Zimbabwe (Stewart et al., 1986). Discussions have already been initiated on arrangements for extension of the research, in recognition of the transfer of agroforestry technology generally being more difficult than that of agriculture or forestry alone. However, both Victoria and Zimbabwe have well-developed networks of agricultural and forestry extension staff who have sufficient mobility and means of communication to give farmers the opportunity to capitalise on the results of the research.

Agroforestry is regarded as having considerable potential to stabilise the productivity of farming systems in Victoria and in Zimbabwe. In both cases, agroforestry features prominently in recently-released documents on government conservation strategies, and government has made a major commitment to developing appropriate research programmes. Victoria is participating in a national agroforestry working group, and Zimbabwe is a member of a regional agroforestry research network (described by Torres, 1986) co-ordinated by the International Council for Research in Agroforestry. Despite large differences in the rural sectors and environments in the two countries, similar procedures have been effective in setting up a programme of agroforestry research and development. These procedures are likely to be applicable elsewhere.

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REFERENCES


ASSESSING SITE PRODUCTIVITY OF INDIGENOUS CYPress PINE FOREST IN SOUTHERN QUEENSLAND

By J. K. Vanclay and N. B. Henry

SUMMARY

Site form, the expected height of a 25 cm d.b.h.o.b. tree predicted from the stand height-diameter relationship, is shown to be a practical and useful measure of site productivity in indigenous cypress pine (Callitris sp.) forests in southern Queensland. Unlike site index, this measure is not based on age and thus has potential for site productivity assessment in stands of unknown or uneven age.

RÉSUMÉ

Il est montré que la forme de station, la hauteur attendue d’un arbre de 25 cm de diamètre à hauteur d’homme (écorce incluse) prévue du rapport hauteur dominante-diamètre, est une mesure pratique et utile de la productivité de station dans les forêts indigènes de Callitris sp. du sud de Queensland. À la différence de l’indice de station, cette mesure n’est pas basée sur l’âge, donc elle a du potentiel pour l’évaluation de la productivité de station dans les populations inéquiliennes ou d’âge inconnu.

RESUMEN

Se presenta la Forma de Sitio (Site Form), definida como la altura esperada de un árbol de 25 cm. de diámetro (dap), obtenida de la relación altura-diámetro del rodal, como un indicador práctico y útil de la productividad del sitio en bosques nativos de Callitris sp en el sur de Queensland. A diferencia del Indice de Sitio, esta medida no se basa en la edad y por tanto sería de utilidad en la evaluación de la productividad del sitio en rodales dísticos o de edad desconocida.

Introduction

Efficient yield forecasting and forest management requires a reliable measure of site productivity. Site index is widely used as a measure of site productivity, but its use is confined to even-aged stands of known age.

This study is concerned with the indigenous white cypress pine (Callitris glaucophylla Thompson & Johnson syn C. glauca R. Br. ex R. T. Baker & H. G. Sm.) forests in southern Queensland. These forests commonly occur as uneven-aged stands dominated by cypress pine, and less commonly as pure even-aged stands.

The species forms growth rings, but apparently "annual" rings are confused by a profusion of "false" rings, and attempts to determine age are quite subjective (Fett and Smith 1975). In this respect it differs from the northern cypress pine (C. intratropica R. T. Baker & H. G. Sm.) which in the tropical monsoon climate of northern Australia forms annual rings amenable to stem analysis (Hammer 1981) allowing site index to be determined. Thus for stands of white cypress pine in southern Queensland site index cannot be used to quantify site productivity and some other measure is required.

1 Department of Forestry, Queensland, Australia.
Review of the literature

Volume production is usually the growth parameter of greatest interest to the forest manager, and evaluation of site productivity in terms of volume is desirable (Sammi 1965). Some measure of volume production as a guide to site productivity in plantations is used in Germany (Shrivasta and Ulrich 1976), Sweden (Johnston et al., 1967), and Britain (Johnston and Bradley 1963, Bradley et al., 1966 also in many other countries e.g. France, Finland, Norway). Despite the superiority of volume production as an indicator of site productivity, site index based on height-age relationships has been widely adopted, principally because volume production is difficult to measure (Mader 1965). However, in stands of unknown or uneven age, some other measure of site productivity is required. Vanclay (1983) identified several measures which are potentially useful for assessing site productivity in indigenous forests. The more promising include visual appearance, natural basal area, stand height and site form.

The visual appearance of a stand may be used to indicate site productivity. Lewis et al., (1976) reported that Pinus radiata plantations in South Australia can be classified successfully into seven site quality classes on the basis of general vigour and form, crown density, needle length and colour, bark tightness and colour, green level and degree of canopy formation. A 3% systematic sample of standing volume is assessed concurrently to calibrate the visual assessment. However, in indigenous forests of varying age and stocking, the method is unlikely to give results more precise than three classes, good, average and poor.

Pienaar and Turnbull (1973) observed that even-aged stands with initial spacings above a certain lower limit converge towards an identical amount of basal area per hectare, determined by the capacity of the site. If the premise that undisturbed sites tend toward equilibrium (Dawkins 1958) is accepted, then the equilibrium or natural basal area may be assumed to be an expression of the site’s productivity (Assman 1961, MacLean and Bolsinger 1973, Adlard 1980). This measure may provide a useful indicator of site for relatively undisturbed forest, but because it is unreliable after logging or other disturbance, it is unlikely to have wide application.

Westveld (1933) argued that the height attained at the cessation of height growth was a good indicator of site productivity. Havel (1975, 1980) used stand height to estimate site productivity in jarrah (Eucalyptus marginata) forest in western Australia. The method fails if logging has removed the large stems from the stand, or if wind has broken the tops of the tallest trees.

Where suitably large stems are not available, the height-diameter relationship may be used to characterise the site. This approach is analogous to site index and some authors (Stout and Shumway 1982, Reinhardt 1982, 1983) have used the height-diameter relationship to derive site index estimates compatible with previously published height-age relationships. Site index is undefined in an uneven-aged stand, and for species such as cypress pine which have unknown and indeterminate age, it is appropriate to use the expected height at a convenient index diameter. Vanclay (1983) proposed the term site form to distinguish the concept from site index.

McLintock and Bickford (1957) proposed an equation based on Meyer’s (1940) adaptation of the Mitscherlich efficacy law (Assman 1961):

\[ H = 1.3 + a(1-e^{-bD}) \]

where \( H \) is height (m), \( D \) is d.b.h. (cm), \( a \) is a site parameter and \( b \) is a constant characteristic to the species. Their work was based on dominant trees selected from

1 Site index is usually defined as the expected height of the dominant trees in the stand at a nominated index age.
stands from a wide range of sites, but not from stands with abnormal stocking or recent logging. They used a series of anamorphic curves, assuming that site would affect only the parameter $a$.

The method was more formally quantified by Stout and Shumway (1982), who gave height-diameter equations which predict site index compatible with published height-age equations for six species in the U.S.A. Their data were also obtained from dominant and co-dominant trees, but taken only from even-aged stands. They examined the relationship of both parameters with site index, and found that only the asymptotic height $a$ was correlated with site, and that the shape parameter $b$ was constant for any species.

Reinhardt (1982) investigated several equations for the height diameter site relationship of western larch, and found that the relationship exhibited a strong polymorphic trend, best described by the Bertalanffy equation. Reinhardt’s equation was:

$$H = 1.3 + a(1-e^{-bD})^c$$

where $a$ and $c$ are constants determined by the site, and $b$ is a species constant. Reinhardt worked with data from pure and mixed stands of western larch, and used the height-diameter curve to predict site index compatible with the height-age equations of Bricknell (1970). Not only were trees on better sites taller at any given diameter than trees on poor sites, but the growth response exhibited a strong polymorphic trend. However, the curves were not well differentiated for trees less than 50 cm d.b.h., and data from trees exceeding that diameter were necessary to establish a reliable relationship. Reinhardt (1983) claimed that accuracy depended upon the variability of the site, but that reliable estimates of site index could be achieved by measuring five to fifteen trees.

Studies by Grimes and Pegg (1979) in spotted gum and ironbark forests in Queensland incorporated estimates of site form derived from hand fitted height-diameter curves. The resulting estimates were found to be reliable and consistent over long periods of time.

Data

During the periods 1937–40 and 1955–58, a total of 117 permanent sample plots were established in southern Queensland on three major cypress pine reserves (State Forests 154, 302 and 328, Figure 1) to gather information on the yield of managed forests. Some of these plots were located using systematic schemes with random starts. Others were based on a stratified sample of inventory plots also located using a systematic scheme with random starts.

The plots are c. 0.4 hectare (1 acre) rectangular plots subdivided into four quadrats on which each tree taller than c. 3 metres (10 feet) is individually numbered, tagged and measured. Measurements were initially carried out every 2–3 years, but the current prescription is to measure every 6 years. Additional measures are carried out at time of logging or silvicultural treatment. The d.b.h.o.b. of every stem is recorded at each measure, but heights and other parameters are recorded less frequently.

Additional data were derived from a series of thinning experiments (Johnston 1975) which were subjectively located in dense even-aged stands of cypress pine regeneration. The majority of these experiments were established during the period 1934–42, and include stands varying from 100 to 4 000 stems per hectare.
Method

The height-diameter relationship in cypress pine was originally investigated as a possible component of a general volume equation (Anon 1979)\(^2\)

\[
V = -0.01514 - 0.006674 \times SF + 0.4240 \times BA \times SF
\]  
(1)

where \(V\) is merchantable volume (\(m^3\)), \(SF\) is site form (\(m\)) and \(BA\) is basal area (\(m^2\)). Investigation of site form \textit{per se} was extended when it was found to have more general application as a measure of site productivity.

The index diameter chosen was 25 cm d.b.h., as trees of this diameter commonly occur in uneven aged stands, are generally still actively growing, and have a well defined conical and undamaged tip, enabling the site form to be determined more accurately.

The Mitscherlich equation:

\[
H = a - be^{-cD}
\]  
(2)

was found suitable to describe the height-diameter relationship. By defining the parameter \(b\) as equal to \(a-1.3\), the model is constrained to predict a height of 1.3 metres at zero d.b.h., and in this form can be easily fitted even to data sets with a very limited d.b.h. range. The model must also be constrained to pass through the index height at 25 cm d.b.h., and thus the parameter \(c\) must be defined as

\(^2\) The volume equation presented here is not the same as that published in 1979, but is a recent and previously unpublished revision.
Analysis of the available data reveals that the asymptote \( a \) is linearly related to site form:

\[
a = -10.87 + 2.460\ SF
\]  

(3)

The overall site form equation is illustrated in Figure 2. Site form can be determined graphically from this figure by plotting the heights and diameters of the individual trees, and subjectively determining the curve of best fit. It is more commonly determined analytically by fitting equation (2) using ordinary least squares.

Six stems within the range 20 to 30 cm d.b.h. are usually sufficient to establish an estimate of site form correct to the nearest metre. Up to ten stems may be required if no stems within this d.b.h. range are available. When the range of stem diameters lies within 20 to 30 cm d.b.h., a simple straight line regression of tree height on diameter can be used to determine site form without bias.

In practice, site form may vary from 10 to 20 metres, but stands of site form less than 14 m are rarely of commercial importance.

Figure 2. Cypress Pine Height-Diameter Relationship.
Comparison with other measures

Site form is comparable with several other measures of site productivity. The asymptote of the height-diameter relationship \(a\) in equation 3) indicates the potential maximum stand height, which exhibits a linear relationship with site form. An indication of site index may be gained by comparing equation (2) with Hammer’s (1981 Equation II) site index equation:

\[
H = 1.3 + (1.284 SI - 1.67) (1 - e^{-0.0302 A})
\]  

(4)

where \(H\) is tree height \((m)\), \(A\) is breast high age \((years)\), and \(SI\) is site index age 50 \((m)\). This equation was based on the two tallest dominant trees in each of 89 competitor polygons. The asymptotes of these two equations (3 and 4) may be related to allow comparison of site form with site index:

\[
SI = -8.179 + 1.916 SF
\]

(5)

where \(SI\) is the equivalent site index \((m)\) with index age fifty years. However, this comparison may not be entirely valid as Hammer observed that northern cypress pine in the Northern Territory exhibited a different pattern of height growth to that of cypress pine in southern Queensland.

Table 1 indicates the correlation site form and several empirical measures of site productivity, based on observations on 416 quadrats:

- A subjective estimate of site quality (1 best, 4 poorest) recorded for each quadrat at plot establishment (1937 to 1955);
- The height of the tallest cypress pine tree observed on each quadrat at any time during the period of measurement;
- The highest basal area observed on each quadrat at any time during the period of measurement, used as an approximation to natural basal area;
- The gross periodic annual volume increment observed over the entire measurement period; and
- The species composition expressed as the percentages of the standing basal area as cypress pine and ironbark \((Eucalyptus crebra F. Muell.)\) at plot establishment.

Table 1 reveals that site form has a stronger correlation with many other measures of site productivity (periodic annual volume increment, maximum observed tree height, maximum observed stand basal area) than does the subjective site quality. Gross periodic annual volume increment is the best indicator of site productivity, but only for
fully stocked stands. The relatively poor correlations presented in Table 1 are due, in part, to the great variations in stocking and stand composition. The correlations given in Table 1 suggest that site form is no better than the maximum height or basal area, but the advantage of site form is that it can be estimated for all stands including understocked and young even-aged stands.

Discussion

Most previous work relevant to site form has used only the dominant and co-dominant trees. Our experience with the relatively lightly stocked (typically 150 to 500 stems/hectare) uneven-aged stands of cypress pine in southern Queensland suggests that it is more important to sample the full range of diameters available, especially near the index diameter, than it is to restrict sampling to some particular stand fraction. However, care should be taken to avoid trees with evidence of top damage.

For some parameter to be acceptable as a measure of site productivity, it must fulfill four criteria:

• It must be reproducible, and be consistent over long periods of time;
• It must be indicative of the site, and not be unduly influenced by stand condition or management history;
• It must be correlated with the site’s productive potential; and
• It must be at least as good as, and preferably better than, any other productivity measures available.

Site form meets all these criteria, and has an additional advantage that it is easily determined from normal inventory measurements taken on a single occasion.

Estimates of site form in uneven-aged stands of cypress pine exhibit remarkable stability over long periods. Most of the plots produced estimates of site form which varied by less than one metre over the forty odd years of measurement. A few plots exhibited variations in estimated site form as small as 0.2 metres in four measurements over a fifteen year period, and only 3% of the plots exhibited variations exceeding two metres over the whole measurement period. Figure 3 illustrates the typical variation in estimates over the range of site form available.

Figure 4 illustrates variation in estimates of site form in even-aged stands following thinning from uniformly high densities in 1941. The depression in these curves in the late 1940s is due to damage caused by severe frosts on State Forest 328 during 1946. Frosts of such severity may be expected to occur less frequently than once in every fifty years (Strochnetter pers. comm, Hammer and Rosenthal 1978). By 1954 most plots appeared to have recovered from the damage incurred during 1946, allowing the stability of site form estimates over time to be appraised. Of the available data, 38 plots were maintained at constant stocking over the period 1954–1980, and were measured an average of 11 times during this period. Linear regression indicated that 21 plots experienced a significant increase in site form over time, 13 plots revealed no significant change, and 4 plots revealed a significant decrease in site form. The rate of change in site form averaged 1.3 cm/year (range +5 to −4 cm/year), and is not correlated with either stocking (stems/ha) or mean site form. Adjacent plots exhibited similar patterns of change in site form, suggesting a component of real site change.

Selective logging sometimes, but not always, influenced the estimate of site form by up to one metre more or less, at the time of logging. There was no relationship between time

3 F. G. Strochnetter, Queensland Regional Office Bureau of Meterology.
since last logging and site form. Similarly, estimates of site form were independent of the year of measure, except during the years 1948, 1966, 1967 and 1971, which returned significantly lower estimates. The low estimates of 1948 and 1971 may be attributed to frost damage in 1946 and to the dieback of the early 1970s.

Thinning in even-aged stands of cypress pine has a relatively small effect on site form in the long term. Thinning dense young stands (mean height 6–7 metres and mean d.b.h. 5–7 cm) from 2000 to 200–400 stems per hectare, gives an average reduction of 0.6 metres in site form (maximum observed 1.8 m). However, in stands where the initial stocking exceeds 2000 stems per hectare, thinning may cause substantial decreases in site form estimates (Figure 4). This is consistent with expectations, as selection of retained stems would favour dominants with good crown depth and greater taper. However, further thinning in stands where mean d.b.h. exceeds 15 cm has only a very slight effect on site form. The thinned stands tend to converge to a site form somewhat lower than that estimated from the original pre-thinning stand, while the unthinned stands remain at the same level (Figure 4). Estimates of site form appear to increase as stands enter the zone of intense competition.

Regression analyses revealed a strong positive correlation between site form and tree diameter increment and between site form and stand basal area increment. Site form is a

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4 Cypress dieback has been attributed to waterlogging and should be regarded as a naturally occurring phenomenon arising as a consequence of normal fluctuation in the environment (Lamb and Walsh 1982).
significant variable in the following equations which predict stand basal area and individual tree diameter increments (Vanclay 1985):

\[
SBAI = 0.04637 \times BA^{1.094} \times e^{0.007402 \times BA \times SF -0.2258 \times BA}
\]

\[
DI = (-0.06357 + 0.007809 \times SF) \times e^{-0.08006 \times BA \times D} \times D \frac{100^{0.5258}}{D -1} \times e^{-0.04421 \times D}
\]

where \(SBAI\) is stand basal area accretion \((m^2/ha/ann)\), \(BA\) is stand basal area \((m^2/ha)\), \(SF\) is site form \((m)\), \(DI\) is diameter increment \((cm/ann)\), and \(D\) is diameter \((cm dbhob)\).

Johnston (1975), using an equation of the form \(\log H = a + b \log D\) found that the gradient of the height-diameter relationship varied with locality, and attributed this to differences in annual precipitation. Thus there is sufficient evidence to suggest that site form is a valid measure of site productivity.

There is one apparent contradiction between the traditional measure of site index and site form in even-aged stands. It is fundamental to the method of site index estimation that height growth depends only upon age and site. In contrast, diameter growth may be dependent upon age, site and stocking (number of trees or basal area per hectare), and this appears to contradict the assumption that site form is independent of stocking. This need not constitute a contradiction if the height-diameter relationship is not affected by
stocking. Evidence from four thinning studies in even-aged stands of cypress pine on State Forest 328 indicates that both site form and top height (and hence site index) are influenced by stocking. All sixteen plots in these studies were thinned to the nominated stocking (stems per hectare) in 1941 and maintained at that stocking for the following forty years. In 1981, the effect of stocking was reflected in both site form and top height. A regression of the form \( \log Y = a + b \log \text{Stocking} \) resulted in a gradient \( b \) of 0.126 (standard error 0.016) for site form, and of −0.130 (s.e. 0.027) for top height. This implies that when stocking is doubled, site form will increase by 9%, and top height will decrease by 9%. Evidently, both site index and site form are influenced equally by extremes of stand density. Despite this interaction with stocking, site index has demonstrated great utility as a measure of site productivity in plantations, and there is no evidence that site form is seriously compromised as a measure of site productivity in indigenous forests.

The final requirement for a measure of productivity is that it should be useful. Site form has proven itself in this regard in Queensland. It is a component of the general volume equation (Equation 1) which is superior to, and has replaced the previous regional one-way volume lines. Field staff make extensive use of site form in selecting forest areas to be silviculturally treated. It is an important variable in growth models for yield prediction (Vanclay 1985). Site form has become a fundamental component of the cypress pine yield regulation system, and is routinely determined in all inventory work.

Conclusion

Site form, the expected height of a tree of 25 cm d.b.h.o.b., is shown to be a useful indicator of site productivity in indigenous stands of cypress pine in southern Queensland. Unlike site index, site form is not based on age and thus has potential for assessing site productivity in stands of unknown or uneven age. Further research is warranted to investigate its potential in other forest types.

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Top height is defined as the mean height of the tallest 25 trees per hectare.


Major changes, not all for the better, have occurred in the last five years or so in the administration of forestry, and are becoming evident in the management of forests in Australia. These have been greater in this period than in the previous sixty-five years. To understand this we must look back to the beginnings of forestry in Australia. Forest management started in earnest with the establishment by the Federal and State Governments of Forestry Commissions and other forest authorities in the first few years immediately following World War I.

Then followed a period of nearly sixty years solid progress in forest reservations, bringing unbridled forest exploitation under control, introduction of timber and grazing licensing systems, development of royalty determination systems, introduction and development of silviculture and silvicultural systems in native forests, achievement of reliable regeneration methods, establishment of softwood plantations, development of fire protection practices and the building up from scratch of forestry research centres and forestry education at tertiary level. All of these apparently had the full support and confidence of the community and Governments during this period. A very great deal was achieved for which due credit is now seldom given in the rush to denigrate past achievements.

Foresters were largely unseen and unknown but, unrecognised by them, their work was becoming more and more visible to a community with leisure to move around and become interested in their environment. Then in the last few years, whilst foresters made little or no attempt to explain their work and objectives and the scientific basis of their activities, there has blossomed what can only be described as an environmental backlash against traditional forestry — what was claimed by the leaders of this backlash to be "insensitive" management of the country's forest estate.

Even though most of this was based on ignorance of forest managers' objectives, perhaps because they had not been adequately explained, the rejection of forestry as seen by these groups continued and expanded with media support until forest management became a major political issue. A determined minority with great skill in handling all forms of media has upset a scientific body largely unable to answer back because they are mostly Government servants.

The management issues have been many and varied. They include clear felling and its alleged ill effects on soil, wildlife and aesthetics; the size of coupes and integrated harvesting for logs and pulpwood for much the same reasons; the possibility of alternative silvicultural systems; wilderness area creation and management, especially access; acceptance of hazard reduction and even fire-fighting at all in wilderness areas; multiple use definition and acceptance; reference areas; flora and fauna guarantees; genetic banks; scientific areas and their management; and any further conversion of native hardwoods to softwood plantations. On these matters, and others of policy, the Institute of Foresters of Australia has regrettably been able to influence community understanding very little. Their voice has been muted and their statements bland because they are mostly Government servants.

No State or territory has escaped this criticism and the result has included restructuring and re-writing of some important forest management practices as well as

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trials of strength between the Federal and State Governments. After sixty years of uninterrupted freedom in managing State forests, State Governments had assumed that under the Constitution that would continue. No longer is this so. The Federal Government has indicated its preparedness to enter the field and use its powers under export controls and those relating to international agreements including National and World Heritage issues to ensure its control and precedence over State legislation. This has produced a completely new ball game under which foresters and forest managers in Australia are now operating. It has incidentally had the effect of placing the spotlight firmly on private forestry and provided it with opportunities to increase timber production activities because of the doubts about continued commitments for timber production from Government owned forests as more are being declared National Parks where timber production is excluded. The field for consulting foresters is also expanding. The Association of Consulting Foresters of Australia now has fifty-one members, compared with twelve in 1980.

The New Zealand experience has been equally traumatic at least for Government foresters, as A. Kirkland described recently in a paper entitled “The Rise and Fall of Multiple Use Forestry”. Many New Zealand foresters are now out of a job due to complete restructuring of forestry administration.

One of the significant features of the public controversies has been the awakening recognition that private property cleared in Australia for farming and grazing purposes is now not all required for food production.

The food surpluses in Europe and over-production in North America have signalled to Australia that high prices for food will be hard to achieve. It is therefore feasible to use marginal farm land for timber production. This achieves the dual objective of helping to reduce Australia’s dependence on forest products imports (about 30% of its total usage is imported) and in the long term reducing the pressure, in some conservationists’ view, on timber production from native forests. Forest industries and the various timber working unions who are now tending to draw together in self-defence, do not accept that there is undue pressure on native forests. A similar proposition regarding land use changes was put to the last Commonwealth Forestry Conference in Vancouver with the U.K. Forestry Commission’s suggestion and supporting argument that there was a strong case for the E.E.C. to reduce the subsidy on food production in Europe and to increase it for wood production to give a more balanced output of what the community needs.

Some thousands of hectares of cleared marginal farm lands have already been converted to timber production throughout Australia. Governments are becoming reluctant to continue their own plantation activity by means of converting native forests on Crown lands to softwoods, except to meet firm commitments to existing industries.

It is partly to achieve a better balance in commodity production that agro-forestry is also becoming more popular on private property and is receiving Government encouragement and support at both Federal and State levels.

Farm forestry joint ventures between pulp and paper companies are also now a regular feature of the build up of future resources for these companies which must ultimately make them less dependent in the future on Crown land raw material.

Let us look at each of the Australian States in turn to gauge the magnitude of the changes that have taken place.

Tasmania and Queensland were among the first to feel the Commonwealth Government pressure. Perhaps it is no coincidence that their Governments were not of the same complexion as that of the Federal Government. In the case of Tasmania, confrontation actually started several years ago on a hydro-electric dam issue — the Franklin dam proposal which was finally decided by the High Court in favour of the
Commonwealth. Compensation was paid to the State and the dam did not proceed.

The next issue was a forestry one, that of logging in some State forests which were regarded by conservation groups as potential world heritage or at least national park status, which was not accepted by the Tasmanian Government. Tasmanian Government and Forestry Commission policy has remained committed to its timber production programme under multiple use objectives which it maintains is not damaging to other forest values in the long term, and furthermore that the State cannot afford the loss of jobs and revenue from cessation of logging operations. The Commonwealth government responding to pressure from conservationists has appointed a Commission headed by Judge Halsham which is examining an area of some 276,000 ha. called the Lemonthyme and Southern Forests area and delineated as National estate and will report and recommend on its future use, including whether it all qualifies for special reservation as World Heritage.

This Commission is now taking evidence from many sources. Initially the Tasmanian Government refused to co-operate in this Inquiry. Its challenge to the validity of the Halsham Commission was dismissed by the High Court in November 1987, since when industry and Tasmanian Forestry Commission assistance is being made available to the Halsham Commission. This Commission has already defined some relatively small areas within the region which it says do not qualify and in which logging can continue. It is due to make its final recommendations to the Federal Government at the end of May 1988. It will be a matter for that Government then to decide whether or not to accept them. It has already made it clear that it is not bound to do so. Tasmania has pioneered the introduction of codes of forest practice for both public and private forests and has had a member of its Forestry Commission specially appointed to assist the private forest owners.

In Queensland, the confrontation between the Federal Government and the State Government related mainly to the rainforests in the north of the State particularly in the Daintree Area. There have been clashes between timber workers who will lose their jobs if the forest is classified as World Heritage, and the Commonwealth Minister for the Environment. Again as in Tasmania the State Government is extremely reluctant to see its control over State forest land assumed by the Commonwealth and is sending representatives to UNESCO in Geneva to try and prevent listing as World Heritage by that international body which would legitimise the Federal actions. Compensation will be paid by the Federal Government for jobs lost and for forest industry losses, the details of which still have to be worked out. Again as in Tasmania, the Queensland Government and Forest Service claims that its management practices are sound and will not cause permanent loss of environmental values.

Victoria is in a slightly different position as it has a Government similar in political persuasion to the Federal Government. This has prevented the same Governmental confrontation situations, but has not prevented confrontation at the cutting edge, i.e. in the forest, between forestry workers and conservation groups. Victoria has a Land Conservation Council whose function is to examine all public land and recommend to the Government on future land use. This in itself has caused controversy by upsetting the timber industry and local communities due to its recommendations and their acceptance by the Government of extensive new National parks which it is claimed will cost timber workers’ jobs. The Victorian Government in 1985 also set up a Timber Industry Enquiry conducted by Professor Ian Ferguson, Professor of Forest Science, University of Melbourne, to examine and report on future forestry policy with respect to regional sustained yield, forest management practices, licensing and log allocation policy etc. The Ferguson Report became the basis, or at least provided the rationale for a Timber Industry Strategy adopted by the Victorian Government, which fixes yields on a regional
sustainable basis and introduces a "value-added" policy whereby logs will be allocated primarily to sawmillers and others who can use them in the manner most calculated to provide added value, e.g. by kiln seasoning and re-manufacture into furniture, joinery, etc. rather than simply as green construction material.

The Victorian Government has followed this with a draft "Code of Forest Practices for Timber Production" — covering both public and private forest land, the details of implementation of which are still being worked out by Government and industry. It has also produced a revolutionary "Flora and Fauna Guarantee" to apply to forest areas having alleged unique or vulnerable flora and fauna to further govern forest management practices to protect these elements. The practical application and effect of this on forest management and silviculture still has to be tested but it has the potential to be very significant and controversial.

Topics such as clear-felling as a management and regeneration practice, hazard reduction by burning to reduce the fuel on the forest floor in either the spring or autumn, and burning in wilderness areas, are other forestry issues which have become prominent and are under investigation. For example, alternatives to clear-felling in intolerant species or fire climax species are to be investigated to see if a "less intrusive" regeneration system can be adopted. Most professional forestry views are that there is no suitable alternative and Professor Ferguson in his Report recommended clear-felling as the most appropriate system, with proper controls, for these species. Most experienced foresters are also very loath to tamper with proven hazard reduction programmes and procedures lest wildfires become even more damaging and difficult to control. Forest administration in Victoria has been placed in an umbrella type Ministry entitled "Conservation, Forests and Lands" where in theory some of these vexing questions will be resolved. Only time will tell whether the apparent downgrading of professional foresters and their long-held beliefs will have a beneficial or detrimental effect on Victoria's forests. One basic fear, especially in fire-prone rural areas is that any reduction in hazard removal, coupled with fewer access roads, as timber production is phased out, and fewer forest workers are available, will put the whole forest estate at greater fire risk.

In New South Wales the issues are similar to those in the other States but again with Governments of similar political persuasion, confrontation at that level has been avoided. As in Victoria, however, there has been at least as much grass-roots and local confrontations between timber and forestry workers and conservation groups. A principal target has been wood-chip export operations near Eden on the N.S.W. south coast. The two principal objections are to the integrated clear-felling type of forest operations which produces both sawlogs and wood-chip logs and the fact that the chips are destined for pulping and papermaking in Japan which therefore gains all the value-added advantages. On the first score, the forests have all been selectively logged over for some 80 or more years, so that the remaining trees are principally below sawlog quality and are preventing forest regeneration. Integrated operations produce some logs and a large quantity of pulpwood material for wood chips. The area then regenerates very well by natural seeding. An early criticism was the large size of the coupes. These have now been reduced considerably and are more aesthetically acceptable. There is still opposition from some quarters however to any wood chip export operation. It is possible that, in the future, pulping and papermaking may be extended into this area and in the neighbouring forests in Victoria. N.S.W. has not imposed the structural changes on its forest administration that Victoria and Western Australia has. The latter has followed a similar pattern to Victoria in structural changes which have seen the forest Service as such absorbed into a much larger ministry. It is too early to judge the effects of this on the quality of public land management, but again foresters in Western Australia had a
proven record of achievement in management of difficult and unique species in a harsh and fire-prone environment. West Australian timbers such as Jarrah and Karri have achieved world-wide recognition and standing.

**South Australia** has been largely saved from the forestry traumas of the other States, having negligible good quality hardwoods and having to rely on plantations of softwoods. This it has done extraordinarily well and is now setting the pace for the increasing role of softwoods in Australia, principally *Pinus radiata*, into what was, only two or three decades ago, predominantly a hardwood economy. No longer is plantation-grown pine just a weed that will provide no competition for either locally grown hardwoods or imported softwoods. The prejudices against softwood plantations in some quarters as "biological deserts" has largely disappeared with the increasing maturity of the stands, the diversity created by mixing of age classes and the development and improvement of recreational activities within the plantations. The "Ash Wednesday" fires of February 1983 destroyed a large proportion of the mature stands but a major salvage programme and storage of thousands of cubic metres of logs in shallow lakes has somewhat softened the blow. Age class distribution for future management and yield regulation has however been severely affected.

The success of softwood plantation forestry in South Australia and increasingly in all States has been seized on by some areas of the conservation movement as the potential "saviour" of native forests, but the movement is ambivalent in its views, many still being of the view that exotic species on such a massive scale as a monoculture should not be encouraged. Unfortunately it takes at least twice as long to grow a hardwood crop to the same economic stage. Hardwood plantation forestry for high class value-added products undoubtedly has a future but must be a long range proposition supported at this stage predominantly by Governments, who have under their control large areas of currently non-productive Crown land, but with high forest potential.

There are numerous areas of difference of opinion still existing on future forest management. It is easy to say they will be resolved but it will take time. For example, the term "multiple use" understood by foresters to be a legitimate and universally accepted management philosophy which includes timber production under proper professional control is now claimed by some conservationists to be simply a ploy to allow continued access to the timber industry. They cannot yet accept that forests are dynamic systems which benefit from management and which at the same time provide social benefits such as employment from a renewable resource. Technical considerations such as three succession, climax species and fire-climax species and their management tend to be dismissed as some kind of ruse to support clear-felling. It is difficult to get across the reality that fire-climax species can die out and be replaced by tolerant species, even though evidence is available for those that wish to see.

There is only one conclusion. The forestry profession, perhaps spear-headed by the increasing proportion of private practitioners must become involved in a major educational exercise at all levels if it is to recover from its recent shattering experiences. Other professions such as architecture, engineering, medicine and agriculture, have learnt how to answer their critics in ways that can be understood and accepted by the community.
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A REVIEW OF FOREST PRODUCTS UTILISATION IN AUSTRALIA

By W. E. Hillis*

SUMMARY

From 1788 European settlers in Australia encountered, in some of the coastal regions, forests of many species which yielded woods with a wide range of often strange and intractable properties. Some such as "red cedar", "sandalwood", and a few eucalypts and cabinet timbers, were exported to obtain valuable income. Research on eucalypts, in particular, and other species has led to developments in wood technology and the establishment of large forest products and pulp and paper products industries. The wood from increasing areas of plantations of *Pinus* spp. has become a major raw material. The possible long-term development of the forest products industry in Australia with its specific geographical and social aspects are discussed.

RÉSUMÉ

Depuis 1788 les colons européens en Australie ont rencontré, dans quelques-uns des régions côtières, des forêts de beaucoup d'essences qui produisaient des bois avec une gamme étendue de propriétés souvent bizarres qui étaient difficiles à travailler. Quelques-uns comme le 'cedrelle rouge', le 'santal', quelques eucalyptus et des bois d'ébénisterie ont été exportés pour gagner des revenus importants. Les recherches sur les eucalyptus, en particulier, et d'autres essences ont mené à des développements en technologie du bois et l'établissement d'industries importantes de la filière bois et papetières. Le bois des plantations d'une superficie croissante de *Pinus* spp. est devenu une source majeure de matières premières. Le développement possible à long terme de la filière bois en Australie avec ses aspects spécifiques géographiques et sociaux est discuté.

RESUMEN

Desde 1788 los colonizadores europeos encontraron en algunas de las regiones costeras de Australia, bosques de composición florística muy variada, los cuales produjeron maderas con una gama amplia de propiedades, muchas veces peculiares y difíciles. Algunas especies, tales como el cedro dulce y el sandal (sandalwood), unos pocos eucaliptos y maderas preciosas, se exportaron para generar altos ingresos. Mediante la investigación con varias especies, particularmente eucaliptos, se ha alcanzado un desarrollo en la tecnología de la madera y en el establecimiento de un amplio espectro de productos forestales e industriales tales como pulpa y papel. La madera proveniente de la creciente reforestación con *Pinus* spp. se ha convertido en la materia prima principal. Se discute el posible desarrollo a largo plazo en la industria forestal en Australia, con sus aspectos geográficos y sociales específicos.

The history of forest utilisation in different countries shows points of similarity. In Europe the hunter-gatherer societies were displaced by the establishment of farming communities and the onslaught on the forests began for the provision of land, food, shelter, fuel and defence. In England, farms or fields probably appeared by 3000 B.C.

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and by about 500 A.D. much of the land was under cultivation so that little of the original woodland or forest remained around the time of the Domesday Book in 1086. Shifting agriculture gave way to better organized open-field agriculture and to villages. Later reorganization of the shared common land resulted in more effective agricultural practices. The previous attitudes that forests were personal or communal properties resulted in loss, inefficient use of land and increasing shortages of timber. The latter resulted in changes, and the first forest nursery was started in Scotland in 1460. In 1482, King Edward IV promulgated a law to exclude cattle from cut-over woodland so as to ensure regeneration. Plantations established on poor agricultural land around 1650 were found to be profitable long-term investments and the 2 million hectares of woodland in England today are reputed to have originated from that drive for plantations. Today with improved agriculture, England with some other countries, is considering the establishment of forest plantations on agricultural land, a step which Australia may also find necessary.

Britain’s long-term concern for timber supplies possibly originated from her need to maintain large navies for the prolonged maritime wars of the seventeenth and eighteenth centuries. In the mid-eighteenth century the 3 700 mature oak trees required for an average warship were taken from English forests and the softwood masts etc. were obtained from European countries. In 1704 an Act was passed to encourage colonial trade in wood. The reducing availability of wood from North America and the Baltic states to equip the British navy provided one of the main reasons for the first British settlement of Australia in January 1788. Within a few weeks of the arrival at a site now known as Sydney, an official report commented on the discovery of “the worst wood that any country or climate has ever produced” and “universally of such bad grain as almost to preclude the possibility of using it”, an opinion no doubt reinforced by the poor quality tools provided to hew the dense hardwoods. Yet despite this and other derogatory reports, forest and forest products activities in Australia have overcome severe obstacles to build an industry which in 1985 employed over 85,000 persons, a turnover of about US$4.4 billion, with value added of US$1.8 billion and export of US$260 M.

It is not possible to present in a limited space, and in a readable form, a balanced or complete review of the utilisation of Australian forests. The following personal survey has necessarily been selective of its topics and attempts to interpret trends in an international context which may help future planning.

After erecting huts and shelters, the first settlers who arrived in 1788 gave their attention to the production of food. Owing to the strange environmental conditions and lack of knowledge, they narrowly escaped starvation within the first few years. From that time, farming activities have been the major national concern and a source of income which resulted in a high standard of living for a largely urban dwelling society. For farming land to be provided, trees were felled and often the best forests provided the best farm land.

Forest Resources

Extensive forests occurred on the eastern coastal zone of Australia from Papua New Guinea to the north, to Tasmania in the south, and in the small south-west region of Western Australia, with a smaller region in the far north of the continent. There were many forest tree genera, the rain forest types were mainly in the north-east region and the dry, sclerophyll or open forests were mostly dominated by some of the 500 or more species of *Eucalyptus*. There were very small volumes of gymnosperms. It was not until
many years after the first British settlement that it was realised the major portion of
Australia was a desert with a low, erratic rainfall (over three quarters receives less than
300 mm average annual rainfall) and very high summer temperatures and evaporation.
This lack of realisation was doubtless responsible for the destruction of forests and
woodlands to meet the ever-increasing demand for farm and grazing land.

Mostly the eucalypts had high (exceeding 30 m), clean boles of large (sometimes more
than 3 m) diameter of wood with a density (exceeding 600 kg m\(^{-3}\)) almost twice that of
pine. The logs required manual conversion into slabs by laborious and unpleasant
pit-sawing with inadequate tools in an often hot climate. Much work was required before
the small ships then available could export the timber.

The Contribution of Feature Woods to the Development of Australia

It was not surprising that as soon as “red cedar” (Toona australis) was found that its rapid
exploitation began. The wood had about one-half the density of eucalypts, deep red in
colour, figured, aromatic, durable, easy to work and took an excellent polish. The trees
were up to 60 m high and diameters exceeding 3 m (at least one was more than 6 m). The
first load was sent to London in 1791, “cedar” was sold in India in 1795 and later in very
large quantities in London selling in 1823 for example at 5.5 to 5.75 pence per superficial
foot. “Cedar” grew scattered in the hinterland of much of a 2500 km stretch of the east
coast of the country. In their search for the trees, the legendary rough and undisciplined
“cedar-getters” did much to explore and open up the country. With their ignorance and
destructiveness, and the ineffectiveness of government control, they also seriously
damaged much forest so that few “cedars” remained by 1860. To place this situation into
context it should be remembered that it was in 1856 that Dietrich Brandis successfully
introduced the first management plan for sustained yield after he examined the
threatened teak forests of Burma.

Sandalwood (Santalum spicatum), a small tree, occurred over much of the southern
parts of Western Australia and was destroyed in clearing the land for agricultural
purposes. When the supply of sandalwood to the Orient from Hawaii and India suddenly
decreased, a trial shipment from Western Australia was made in 1845 and 3 years later,
1,335 tons earned more than one-half the export income of that colony. The amount
exported for perfumery purposes reached an all-time peak of 13,945 tons of heartwood
during the year 1920 but the availability and export has declined considerably in recent
years.

There were very large volumes of jarrah (Eucalyptus marginata) in the south western
corner of Australia and an important export trade commenced with 200 tons in 1836.
Since then enormous quantities of this dark-red, mahogany-like timber have been
exported to the UK for use as pavement blocks, railway sleepers, heavy construction
work and so on. Its popularity as a high quality furniture and feature timber has
increased in recent years. The area of jarrah forest affected by the root rot fungus
Phytophthora cinnamomi has enlarged significantly since 1945.

In the early periods, English “cabinet makers” used to a limited extent species such as
sheoak (Casuarina stricta), Queensland silky oak (Grevillea robusta), blackwood
(Acacia melanoxylon), rosewood (Dysoxylum fraseranum) and black bean
(Castanospermum australe). However many of the “brushwoods” were either not used
in a manner to reveal their beauty or were destroyed. One of the reasons for this was that
the cost of transport often exceeded the value of the wood, another was that suitable
methods for their processing and use were at that time unknown.

The Cypress pines (Callitris spp.), that were formerly abundant in the inland regions
of New South Wales, reached 30 m height and 0.9 m diameter. Perhaps 100–150 M trees were removed around the 1850s with the encouragement, and even the demands, of politicians to provide rich land for agriculture and pasture. The high durability and termite resistance encouraged some local use of the timber as railway sleepers, posts, bridges and building material. The low regard for the timber probably restricted the distance it could be transported. Now the attractive, figured golden brown wood with a pleasant aroma is prized as a feature and furniture timber, but supplies of large-sized material are limited.

In addition to the magnificent forests of "pines" (Araucaria spp.) Queensland had many subtropical species with the potential to provide high quality furniture timbers. When E. H. F. Swain became Director of the Forestry Department he commenced a programme to develop silvicultural procedures to maintain the productivity of these rain forests. He saw that this depended on efficient conversion and utilisation of their timbers, and initiated a vigorous programme in the early 1920s to develop the identification and utilisation of more than two hundred local species, and to grow quality wood. In 1931, Swain fought against the conversion of the rainforests in North Queensland to agricultural land which he viewed as an exercise motivated entirely towards ensuring electoral success. A government enquiry found that Queensland did not need forestry science and that it suffered from too many trees; Swain's services were terminated. When Swain became Forest Commissioner of New South Wales in 1935 he again encouraged, among other things, the greater understanding and improved use of the secondary species of that State. As a result of that policy, wood technologists of the Commission were able some 25 years later to persuade the architects of the internationally known Sydney Opera House to use Brush Box (Tristania conferta) and White Birch (Schizomeria ovata) for the floor, walls, ceilings and seats. They now serve their purpose admirably, and are much appreciated. In Swain's time they had been regarded as rubbish, but research had accumulated a large amount of data to show they could meet many stringent requirements. Swain's stimulus has resulted in a number of Australian secondary species providing prized feature timbers. Indeed some of them were to be used in the new Parliament House in the national capital. However this time, environmental vigilantes prevented the conversion of logs from North Queensland which had been taken from an area which had become politically sensitive.

The Use of Eucalypts and Pines in Australia

Although eucalypts were, and remain, the dominant feature of Australian forests, it is only recently the woods from them have begun to receive the recognition they deserve. With a few exceptions, the large number of species grow in relatively restricted regions and in mixed species forests. This has lead to their use as mixed species and only occasionally as single species (such as jarrah, karri, mountain ash, blue gum, red gum). The early settlers found the eucalypt woods had unusual properties and defects but notably their density was much greater than that of the European softwoods. From the beginning the design and quality of the cutting tools were continually improved to process the material. In 1795 the report that "all woods growing in New Holland (Australia) are much given to heart rent and shakes", is probably the first reference to growth stress in eucalypts which still remains a problem in sawing eucalypts although ingenious techniques reduce loss. The high density and the tendency of some species to split when nailed resulted in house-frames being built with undried wood using bracing to minimise distortion on drying. Prejudice against the use of eucalypt wood resulted in the importation of large amounts of sawn wood notably Oregon (Douglas fir) and Baltic pine for building purposes. Also the increased conversion of forests to agricultural land
during the severe economic depression in the 1890s later resulted in local shortages and New South Wales for example began in 1906 to import for a period from west Australia.

Empirical developments by some of the many small sawmilling enterprises increased the use of less favoured species and the efficiency of conversion of the well known ones. These developments, made in isolation and mainly to solve immediate problems, were inadequate for the comprehensive development of a complex resource required for increasingly sophisticated needs. Eventually in the 1930s the Commonwealth (Federal) government and the State governments set up technical groups to convey greater understanding of overseas developments to the local forest products industries. It was soon evident that the adoption and adaptation of that knowledge was inadequate for a resource of such different properties and that research of the local material was essential. The different laboratories examined aspects according to local priorities and over the long term their complementary findings have made major developments in wood technology.

The development of standards, not only for common names of timbers and for terms but particularly for grading rules became an early (1930) and continuing task. On the one hand, in the past some specifications required a quality “free from all defects” whether the defects affected the intended use or not, so that large quantities of timbers were wasted to provide the highest quality. On the other hand, because of the need to remove trees to provide land for various purposes, and the difficulty in using a number of timbers, the disrespect for local timber often resulted in inferior preparation, presentation and use when required for non-specified uses. The shortages of timber, particularly in wartime, called for a greater understanding of property requirements for end use, and together with the increasing competition between hardwoods and exotic pines, there resulted an improved appreciation of local and appropriate grading standards. Green “off-saw” and dried hardwoods were graded visually to meet most requirements satisfactorily by using a conservative approach to accommodate defects.

Probably the greatest single factor obstructing the wider use of Australian hardwoods and particularly eucalypts before the 1930s was the reputation they had obtained as being liable to shrink and warp excessively when dried. Many believed these characteristics were inherent and unavoidable. Some of the hardwoods were much more prone to collapse during drying than were almost all timbers of other countries. Their frequently excessive form of shrinkage resulted in an irregular shape of the dried piece of timber, with corrugations and uneven sinking of the surface and frequently accompanied by internal checks. Two saw-milling brothers discovered around 1920 that most collapse could be permanently removed by steaming the timber at the conclusion of drying. Subsequent research defined the best conditions of “reconditioning” to take advantage of this discovery and developed a range of drying schedules to minimise the development of collapse and the associated checking. The “ash” group of eucalypts collapse freely, and check rather readily when backsawn. As it is the timber itself which limits the rate of drying, various procedures and innovations have reduced surface checking on drying and current studies of basic processes coupled with electronic control of drying will result in minimum degrade and increased production of appearance grade timber.

Among the early studies was the determination of strength characteristics of clear specimens of major local species. These data were to play a significant role in at least two important developments namely the grouping of species according to their strength characteristics, and the stress grading of timber.

The specification of particular species for certain purposes resulted in waste with a resource of mixed species such as is found in Australia. The proposal (originally in the late 1930s) and acceptance of the use of species according to their strength grouping led to a much more efficient use of the mixed resource when for example about 80 eucalypt
species were used extensively. The acceptance of this strength classification system provides a framework into which the multitude of neglected lesser-known tropical species can be fitted efficiently.

The data showed that timber frames built with local and dense hardwoods were unnecessarily strong and wasteful of timber. The necessity in World War II to conserve material assisted the development of a Light Timber Framing Code which assumed certain strength properties for the various components of the building. This further encouraged the use of visual grading and the strength grouping system.

*Pinus radiata* was first planted in South Australia about 1865. Its rapid growth in a country short of softwoods resulted in the establishment of several plantations there and in other States. At first the wood was used mainly for fruit cases, then to meet the pent-up demand for construction timber in the post-war period, it was sold in the undried state as was hardwood. Because a considerable proportion was juvenile wood, pine twisted badly on drying and subsequent legislation permitted its sale only as dried wood. However, visual grading did not separate reliably the weaker juvenile wood into the grades for engineering purposes. At this time the long lengths of hardwood were becoming less common, the roof truss industry requiring shorter pieces of required strength was developing and the Light Timber Farming Code was being widely accepted. Earlier the physical and mechanical studies of wood properties had shown that modulus of elasticity (stiffness) of a piece of timber containing defects was an indicator of modulus of rupture (strength). (This was contrary to overseas opinions that defects had no significant effect on stiffness). Using this relationship, the development of a relatively low cost machine-stress-grader was commenced in the mid-1960s to assign accurately the strength of a piece of timber by a non-destructive method. Today, pine structural timber sold in Australia must carry a graders strength denoting colour marking. A less expensive proof grading machine is being developed which is suitable for small mills using mixed species but producing only one stress grade.

Shortly after the development of the machine stress grader, a high temperature drying procedure for distortion-prone and other pine wood was developed in Australia to produce not only more dimensionally stable material with reduced shrinkage and fewer defects but at lower costs than timber dried at lower temperatures. Most softwood in the country is now dried by this process. These technical developments together with improved marketing and increasing availability have resulted in increased consumption of coniferous woods and 6 M m$^3$ were consumed as sawnwood and veneer in 1985–86 in comparison with 5.5 M m$^3$ of hardwood. This is a marked change from 1790–1971 when 1.27 M m$^3$ of softwood sawlogs were used and 7.32 M m$^3$ of hardwood sawlogs.

In contrast to most northern hemisphere woods, the sapwood of almost all Australian hardwoods contains starch. In addition the size of the vessel is large enough for the eggs of the powder post borer (*Lyctus* spp.). This beetle became one of the most serious pests of dry wood in the country. While in locally grown eucalypts the sapwood is narrow (about 2.5 cm), in a number of other hardwoods it is wide. To eliminate lyctid attack, in 1945, some regions insisted that the sapwood of commercial species should be treated with a boric acid type preservative. Sodium fluoride was introduced to overcome problems with adhesives and a boro-fluoride-chrome-arsenic diffusion preservative was developed. The very high solubility in cold water of the latter enabled green timber of scantling size to be dipped momentarily and then stacked to allow diffusion. This process has also been used successfully elsewhere.

The Australian climatic conditions are conducive for the activities of a number of destructive organisms. Originally, native species (such as some eucalypts, cypress and huon pines, *Syncarpia* sp.) supplied durable woods for a variety of special needs (piles, boats, sleepers, house-stumps, posts); their resistance to termite attack being
particularly valuable. As desirable timbers became scarce the importance of the preservation industry increased as the treatment of available pine (Pinus spp.) provided acceptable alternatives. Water borne copper-chrome-arsenate (CCA) is widely used in amounts of 3,500 T/annum. High temperature creosote is used in an annual volume of more than 5 million litres, and it is probable that its role will be taken over by the locally developed PEC (pigment emulsified creosote) of various forms. Commodities treated with this development are cleaner and drier to handle than those treated with conventional creosote and PEC does not bleed from them even when cut.

Australian trees provided a number of “minor” forest products such as tan bark (from Acacia mearnsii, Eucalyptus astringens), essential oils (the leaves of Eucalyptus spp. were once the major global supplier of certain chemicals), pharmaceuticals (rutin, hyoscyamine, kino), and cork (from Melaleuca spp.). High local costs have greatly reduced the competitiveness of local production of these materials.

In varying degrees, eucalypt species when injured produce a dark reddish exudate, rich in polyphenols (tannins), in the cambial region. The exudate appearing on the bark was incorrectly called “gum” (which is a carbohydrate material) by the early settlers and gum trees have become a common name for eucalypts. Fire is the most common initiator of the formation of kino which is contained in veins or pockets in the wood or bark as well as exuding. Eucalypts evolved with the regular use of fire by the aborigines, to assist food gathering. Since then the accumulated forest litter, the high content of inflammable oils in the eucalypt leaves aided by hot, dry, windy climatic conditions have resulted in periodic, large-scale and devastating bush (forest) fires which result in severe cambial injuries (and death) and significant kino formation. Kino (gum) veins and pockets are the most commonly mentioned defects which downgrade eucalypts in timber quality standards.

The heartwoods of different groups of eucalypts vary from dark red, brown to light tan in colour, due to the presence of different classes of extractives. The heartwoods in mature trees contain large (15–30%) amounts of polyphenolic extractives. When wet the tan-coloured eucalypts in particular quickly stain blue with iron and for this reason pulp and paper making equipment is built with stainless steel.

Various experts from other countries condemned proposals to use eucalypts as a source of paper pulp. After an examination of pale-coloured eucalypts of Tasmania, one overseas pulp and paper expert was unable to recommend (in 1915) their use for commercial paper production because of the short length of the eucalypt fibres, the very low yields of poor quality pulp and the cost of bleaching. However research initiated by I. H. Boas in Perth, Western Australia two years later, showed that the ratio of length to diameter of eucalypt fibres was indeed favourable for paper making and that only mild pulping procedures were required to give adequate yields of pulp with suitable properties. These studies led to the establishment of a local pulp and paper industry producing today almost 2 MT/annum of paper and paper products based mainly on eucalypt mechanical, semichemical and chemical pulps, with a workforce of over 8,000. In addition about 5 MT annually of eucalypt wood chips from low grade logs and sawmill residues are exported for the manufacture of pulp with crush-resistant properties. These achievements have resulted from the intensive basic and applied research by government and the industry’s laboratories and their co-operation over many years, which also resulted in new principles of wood ultrastructure and extractives being established.

Future of Forest Products Utilisation

In 1984–85 the value of turnover in the Australian wood and wood product industries was about US$2.35 billion and in the paper and paper products about US$1.90 billion,
with the former employing over 48 000 persons and the latter 23 000. For several years
Australia has imported about one-quarter of its needs of forest products with a value of
almost US$1 billion in 1985–86. It will always have a considerable demand for forest
products as well as a potential to increase its exports of about US$240 M (including $165
M for woodchips) in an international trade worth $50 billion. What type of products
could it export?

By western standards, there is a considerable shortage of forest products per capita
throughout the world and this is worsening with population growth. Until recently this
situation was used by many countries as a basis for plans for plantations. However it is
now evident that, despite aid and assistance of various kinds, the large majority of the
global population will be unable to purchase forest products. Indeed most of that
majority, if they have not already done so, are depleting their, mainly hardwood, forest
resources for international finance, or are destroying the forest cover for essential land
or fuel. It is now clear that the demand for use of resources is related much more to rising
per capita income than to a rapid increase in population. Those countries with
satisfactory incomes can purchase two types of wood — general purpose forest products
and high-value or feature products. The consumption of general purpose forest products
is related to building construction but the relatively static populations in industrial
countries have decreasing housing demands. They do have an increasing demand for
higher-valued products.

About three-quarters of global industrial wood supplies come from natural forests
which for various reasons will contribute less wood than expected in future although the
hardwood forests of the USA are in a period of very rapid inventory increase. Annual
plantation establishments globally, mainly with pines and eucalypts, are only one-tenth
that of current forest loss. Some plantations have or are yielding wood of inferior quality
whereas others, such as the most recent clones of eucalypts in Brazil, yield more than 70
m$^3$/ha/year of wood with improved properties for pulps.

No one forestry plan is suitable for the diverse conditions in Australia. It is necessary
to maintain and increase in strategic locations, large and reliable supplies of wood for the
construction, pulp and paper, and panel-product industries so that investment and
employment are encouraged and competitiveness raised. Long term planning is difficult
because developing technologies and the ingenuity of industry and the market place
could render a successful product of today (or its properties) uncompetitive before a
plantation is ready to be harvested for that product. The development of the board
industry using small-sized to replace large-sized raw material is an example (the
Australian particle board and fibreboard industry produced about 800,000 m$^3$ in 1985–
86). Can Australia provide uniquely attractive forest products that will avoid the
problems associated with the unco-ordinated reforestation plans of different countries
and regions? Should it enlarge its plantations of softwoods or develop hardwoods to
supplement those in the tropical timber trade with a reputed annual turnover of about $7
billion? Does Australia have the resources to develop further its forest products
industries?

Australia today has

- a large, mainly dry country, needing land protection, water conservation and large
catchment areas, with a very small capacity for human population
- a high availability of free solar energy, of coal and minerals
- 7.3 M ha of eucalypt forests managed for wood production, 2 M ha of rain forests
  and 32 M ha of low quality eucalypt, paperbark and cypress pine forests, there are
  4.9 M ha National Parks
- an increasing area of uneconomic agricultural and grazing land due to loss of world
  markets, and to land degrade
FOREST PRODUCTS IN AUSTRALIA

- a small (16 M) population, with over 70% in 12 widely separated cities, with a huge international debt and high transport costs to markets
- an expensive workforce with wages increasing at twice the rate of industrial countries, high (14%) interest rates and a 8% inflation rate
- a politically strong anti-forest utilisation lobby.

General purpose forest products

Australia has established 780,000 ha of plantations of Pinus spp. (and almost 46,000 ha of Araucaria spp.) increasing at a rate of 25,000 ha annually. For many years improvements have been made in the quality of those plantations and in the processing of the wood in order to meet local needs and the demands of the Pacific Basin, the world’s fastest growing economic region. Japan imports annually about 60 M m³ of logs, sawn wood, veneer, chips and pulp, but the recent rate of increase of its housing construction (and consumption of general purpose timbers) is likely to decline.

Over the past 15 years rapid increases in the rates of production of general purpose wood from plantations of Pinus spp. have occurred in the Pacific Basin. The area of plantations is now 35 M ha and the major plantations are in Chile with its 1.2 M ha to increase to 1.6 M ha and New Zealand (about 1 M ha). Chile now consumes only 35% of its production of 11 M m³ which will rise to 24 M m³ in 12 years. The Pacific region could produce as much as 80 M m³ annually of mainly small to medium diameter pine logs in 15 years, or 30% more than Japan’s current total import of forest products. Even Fiji will produce 1 M m³ or about 20% of Australia’s present softwood production. Under some conditions there could be a possible surplus of general purpose wood within the Pacific Basin within a rotation period of about 30 years.

In addition, the current development of the vast Siberian resources could release large amounts of high quality, pale-coloured timber to the Pacific Region. A substantial portion of this could be taken by the expanding (but tightly controlled) Chinese economy, particularly after the recent forest fires in China which destroyed 25 M m³ of trees and logs. Furthermore, the development of various types of board manufacture and wood-laminates from low gluing procedures could increase the supply of general purpose forest products. Also improved and different preservatives will further extend the service life of forest products.

Australia has developed the efficient manufacture of high quality pulps and papers using its native and often poor quality eucalypt resources. However the export market of the increasing demands worldwide for eucalypt pulps will become increasingly competitive in the long term and favour woodchips of single species grown close to ports or pulp from highly-selected, rapidly grown trees of superior wood quality in low labour cost countries. The annual production of two Brazilian companies is already over 800,000 T of eucalypt pulp and they are currently planting more than 300,000 ha/year. By comparison Australia has about 36,000 ha of eucalypt plantations.

The area and productivity of intensively managed eucalypt forests and plantations in Australia could increase in certain regions to supply the efficient local industry providing high quality pulp and forest products for national requirements. This would result from current research to improve plantation management techniques, eucalypt regrowth utilisation and laminated wood techniques.

High-value forest products

The demand for feature timbers is increasing but is affected by continuity of adequate supplies, uniformity of high quality, and reputation. National preferences and fashion
also govern demand. Relatively few feature, high-quality timbers are grown in the Northern Hemisphere and for centuries various appearance-grade timbers have been imported from tropical countries. Feature timbers are mainly hardwoods and their export of 4.2 M m$^3$ in 1950, rose to 53.3 M m$^3$ in 1973, and 66 M m$^3$ in 1980. The availability of these timbers is progressively decreasing due to population increases and exhaustion of supplies. Furthermore conservation groups have begun to ban the purchase of hardwoods from some regions.

Feature timbers can command high prices when used for furniture, flooring, wall linings, and where their inherent properties of very high strength and abrasion resistance are required. Top grade furniture timbers can fetch prices 5–20 times those of sawn general purpose timbers. Very few tropical feature woods have been commercially grown, with teak being one exception. High-value, high-quality woods could have a more secure place than general purpose products when their irreplacable features have a special function.

At one time Australia had a richness of feature timbers covering a wide range of colours, textures and other wood properties, many almost eliminated in the conversion of forests to agricultural land. Although past research has resulted in improved growth rates, wood quality and utilisation of Pinus spp., a relatively insignificant amount of funds has been available to develop the management of rainforest species to provide feature timbers. (Plywood from feature timbers was first made in 1907 but now the 95,000 m$^3$ annual production is largely veneer over a cone or pine). So far little, if any, attention has been given to the selection or conservation of the genotypes of, for example, the highly prized fiddle-back blackwood or curly jarrah, or the red or mahogany-type timbers. Future usage of feature timbers will require more research of the nutritional or other requirements to boost availability. For example, more research, on drying to eliminate distortion and checking, stabilisation of dimensions and colour and adhesives for particular timbers. An integrated approach to forestry and forest products will be required to supply the highest quality appropriate to the needs of the market. Continued improvements in systems analysis techniques will assist the introduction of complex multiple-use management concepts to gain maximum economic advantages with specific species. These species would be chosen not only to suit the particular land type and environment to facilitate land rehabilitation and improvement but also to produce high-value feature woods that would cover high local labour and transport costs.

The current economic criterion of short-term economic gain is not satisfied by the high initial costs of establishing these woodlands. High labour and interest rates and long rotations of over 50 years before realisation of produce will discourage investors. However the increasing (and in some cases urgent) need for land protection, and for national welfare, justify greater government attention and financial encouragement. It is essential that governments are committed to maintain secure supplies of wood for industry and an environment encouraging further investment. This will require informed public opinion. Australia has greater opportunities than most other countries to develop forestry for the benefit of future societies. However, single interest groups, aided by a largely incoherent and irresponsible mass media have distorted views of sensitive areas at great cost to public authorities. The recent establishment of a senior industrial body to combat these distortions should restore the balance and inform society of its enormous dependence on the innumerable forest products it uses and the beneficial nature of forest industries.
REVIEWS

Requests for any publications received or noted below must be addressed to the publishers and NOT to the Association.


This pocket-sized, soft-covered manual in 3 parts is written by the well-known French forest botanist, Dr. René Letouzey, who has practised both as a forester and as a taxonomist in francophone W. African territories, particularly Cameroun, and on whose flora he is a recognized expert.

The text in volume 1 discusses the organisation of the plant kingdom and its main systematic groups and the different types of vegetation throughout the world. This is followed by longer chapters describing, in considerable detail, the structure of the different parts of a flowering plant from roots to flowers. There are final chapters on how to collect and prepare plant material as herbarium specimens and an all-too brief discussion in non-technical language, of the principles of plant nomenclature.

Volumes 2A and 2B are of about equal length and contain thumb-nail sketches of the major flowering plant families represented in the W. African flora (including Gabon and Central Tropical Africa). The accounts set out to provide both theoretical and practical ways of distinguishing between each family and between the genera and species which are of particular interest to foresters. An indication is also given of their habitat and economic value.

Silhouettes of tree architecture and clear line drawings (up to 4 pages per family) showing bole-form, bark characteristics, leaves, flower and fruit structure and floral diagrams illustrate the diversity of form within each family. The drawings are particularly instructive as no keys to identification are provided. Families mentioned which may be unfamiliar to British foresters with experience in W. Africa include Luxemburgiaceae (near Ochnaceae) from Gabon, Dioncophyllaceae (Sierra Leone to the Congo) and Octoknemaceae in Ivory Coast and Zaire.

There is no other book in English which treats this subject so thoroughly and so competently. It should find a ready market in the UK and in the English speaking countries of W. Africa. I strongly recommend it.

B. T. Styles

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**Imported Timbers in New Zealand,** by Stuart C. Scott.

Of this small book of seventy-seven pages, fifty-four pages are devoted to forty summary descriptions of the principal timber species imported into New Zealand. The timbers are classified by the country or region of origin. The remainder of the book comprises a number of short paragraphs on several subjects such as the difference between hardwoods and softwoods, timber seasoning and timber borers. There are two pages of good quality colour plates of twelve timber species and two pages of colour plates showing the domestic utilisation of timber.

Each timber is described under the standard headings — characteristics, durability and strength, seasoning, working qualities and uses. There are, where required, brief
references to the country or area of origin and to alternative names. There are also, scattered through the text, occasional vignettes of general interest, often of an historical nature.

In his efforts to avoid complicating the text the author has, in a few cases, so over-simplified as to be a little misleading. For example, the description given for rosewood applies to *Dalbergia nigra* but is not really applicable to *Dalbergia latifolia* or to many other rosewoods. The reviewer is not familiar with the conventions used in New Zealand but in Britain the terms softwood and hardwood are simply the timber equivalents of the botanical expressions conifer and broadleaf. It is not, therefore, clear why the expressions should be confusing and unsatisfactory.

It is stated in the Foreward that the book was written for a wide ranging audience rather than for the expert and on that understanding the author has produced a publication which will be of undoubted value to many people concerned with imported timbers in New Zealand.

D.R.J.

*Commonw. For. Rev.* 67(1), 1988


Publication of volume III sees the completion of this great and remarkable work in an English edition. More than 5000 species and 6000 cultivars grown in the temperate parts of the world are covered in the complete work and in this part we have treatments of such large and widely cultivated genera as *Prunus, Quercus* (33 pages), *Rhododendron* (77 pages), *Rosa* (36 pages), *Sorbus, Syringa, Ulmus* and *Salix* (28 pages). Besides accurate and concise plant descriptions of each taxon, details are given on the uses that woody plants can be put to in the garden, their cultural requirements and place in garden design or landscape. Many are illustrated by means of line drawings or *in situ* high quality black and white photographs. Keys are provided for the larger groups. The overall treatment is very broad, such that many plants dealt with are rarely grown in the British Isles and are in fact unknown even in specialist collections or botanical gardens. To help with questions of possible future introductions, information is provided (by K. Beckett) on the general question of hardiness and the so-called "hardiness zone" rating as applied to Great Britain, where the climate is so unpredictable and frequently treacherous to plant life.

This final volume of the three has a lengthy list of multi-language equivalents of botanical terms, a taxonomic outline of the families and genera covered in the complete work, plus 25 pages giving abbreviations of authors’ names. Finally, there is a useful list of registration authorities for cultivar names. As in with the previous two parts, there is no index.

The three volumes of the complete work will cost in excess of £150.00, which means it will be out of the financial reach of most plantmen. It should be purchased by all larger libraries with botanical, arboricultural or horticultural interests as an important reference source.

B. T. Styles

The literature available for the information of field foresters on tree disease problems in general is sparse, and there is even less on the pathology of those tree species now widely planted in tropical industrial plantations.

Dr Ivory's handbook goes some way to remedy this shortfall with respect to tropical pines, providing an up-to-date account of their diseases derived from the literature and a series of visits to regions where tropical pine plantations have been established (Project R.3809 of the Overseas Development Administration). The latter was in some ways a sequel to a study of Central American pine pathogens made by Dr H. C. Evans (ODA Project R.3410) and published as CMI Mycological Paper No. 153.

The subject matter is presented clearly and concisely, and will be of greatest value to forest pathologists and forest research officers in other disciplines. Field officers with some knowledge of mycological terminology will also gain much from the book, as well as students.

The work deals mainly with fungal pathogens and higher plant parasites (mistletoes); only one nematode is mentioned by name and no bacterial pathogens are included. The basis of the book is outlined and the concept of disease is defined in an introduction, followed by a chapter on diseases subdivided into sections dealing with seeds and seedlings, root diseases, foliage and stem diseases and cone problems. Brief accounts of environmental and nutritional disorders come next with a similar section on animal damage, covering nematode, insect and mammalian attack. In all of these, special attention is paid to conditions where the symptoms might be confused with those of a true disease. There is a short section on mycorrhiza and twelve pages on secondary organisms. The latter includes weak fungal pathogens and fungi associated with pine tissues in an almost purely saprophytic role. Some pathogens are also noted which have proved pathogenic to living pine tissues but have not yet been found to be aggressive under tropical or subtropical conditions.

There is a complete bibliography and three appendices which list respectively the tropical pines treated in the work, a useful host/disease table and notes on techniques and equipment to help the officer who has the training and equipment to collect material in the field and make preliminary microscopic and cultural examinations.

A good index completes the work.

There are excellent line diagrams to illustrate the reproductive structures of the more important pathogens, supported in many cases by good colour photographs.

This work is of particular value as it brings together, in clear and simple form, advances that have been made in tropical pine pathology in the last decade. In this respect, the treatment of the more important needle pathogens, the distinction between the several Armillaria spp., now recognised as the causes of Armillaria Root Rot, and the status of Heterobasidion annosum (and H. insulare) with respect to tropical pine plantations, deserve mention.

It is to be hoped that provision will be made to revise and update this work as necessary, and that it will provide a pattern for similar works on the diseases (and possibly, the insect pests) of other species important to tropical forest plantations.

When, for instance, can we hope to see a similar treatment of the pests and diseases of eucalypts?

I. A. S. Gibson.

Within its 47 pages this report includes a great deal of information and ideas. In the days of Bourne and Troup at Oxford, much interest was taken in the classical approaches to forest management on the continent of Europe, although little was regarded as easy to apply in Britain. This paper is a symptom of a welcome return of interest and activity in broadleaved, uneven-aged, silviculture at the Oxford Forestry Institute.

In 1982, the main author published a detailed study on the economics of silvicultural options for broadleaved woodland in Britain, and the paper under review has been derived by him from his D.Phil thesis, together with his supervisor. It covers research into the management and economics of different ‘non-plantation’ silvicultural options and proposes a classification of them into coppice and high forest systems, the latter then being divided into ‘clear fell’, ‘shelterwood’ and ‘selection’ systems. Within each of these there are ‘group’ and ‘strip’ management variants. The authors note that there are very few examples in Britain of silvicultural systems other than clear-felling, and they relate this partly to lack of consistent management, and partly to Government policy over reafforestation. They have interesting comments to make on the approach to natural regeneration in Britain which they say is too often of a ‘laissez faire’ nature, with insufficient intensive intervention to ensure success. True, to the visiting British forester, natural regeneration in Europe always appears to be ‘easier’ than in Britain but in Europe the plantation tradition, which in Britain is strongly supported by fiscal incentives — is much less widespread.

The analysis of management and investment options is particularly useful in considering the suitability of low- or high-input systems for different classes of woodland owner. The distinction between high management inputs, for the production of small quantities of high grade timber from complex forests, and high capital inputs for large outputs of plantation material, is well brought out. There is a list of 77 well-chosen references, and an appendix describing the procedures used in the economic analyses presented, which give net present values in perpetuity at a discount rate of 3%. The book is a valuable contribution to the increasing interest in practical ‘other’ silvicultural systems in Britain.

P. J. Wood


This book is a celebration of forestry in Cyprus during the period of British administration, 1878–1960, and in particular an appraisal of the contributions made to the organisation and development of Cyprus forestry by the successive heads of the Forest Department.

The introductory chapters, comprising the shorter Part I, set the background for the conditions obtaining in 1878, and provide a concise record of the island’s history, physical features, people and economy, and of the history of its forests leading to their abused and depleted state at that time.

The main part of the book then recounts in considerable detail how the many problems came to be tackled, sometimes with success, often with setbacks, until eventually there was forged not only a highly respected and efficient Forest Department,
but also understanding by the people of the essential role of the mountain forests in their contribution to water supplies, soil conservation, recreation, tourism, employment and forest products. The author deals successfully with these two strongly related themes. On the one hand, there is the development of the Forest Department itself — the creation of the infrastructure in roads, buildings, telephone system and the like, mostly in remote and difficult terrain; the recruitment, training and education of staff; the introduction of forest management and yield control. On the other, there is the long campaign for improvement in land use in the hills and the lowlands, bound up with the issues of free range grazing by goats, fires, soil conservation, water supplies and demands for timber and wood fuel.

It is demonstrated that there was remarkable consistency in policy in the Cyprus Forest Department from the outset, but the methods by which it was sought to be implemented varied with the times, the funding available, and the personality of the head of department. Much failed to be achieved until the department was competently staffed, and then only by seeking to work with the people, rather than trying to impose the department's will upon them, but always with the same constancy of purpose and pride in the mission and custodianship. There are no doubt lessons here for policy makers, administrators, and other land users' as well as foresters, and the book is worthy of a wider readership than those especially interested in Cyprus.

Regrettably there are a few blemishes. There are some spelling and some typographical errors. At one point, the area of the forest estate is given as 1,425,375 km\(^3\) (sic) when presumably what was intended was 1425.375 km\(^2\). The photographs of the Heads of Department omit any reference to Dobbs (1822–85), and Bovill is credited with having taken up office in 1882 instead of 1886 to mask this omission.

There are copious notes enumerated in the text and these notes then appear as an Appendix. It is tiresome to keep having to turn to these notes as one reads (Chapter 8 has no less than 90 notes) but more importantly, there is frequently much of substance in the notes which could have merited incorporation in the text. There is also some repetition: an identical quotation about the Cyprus peasant's attitude to wood appears both on page 79 and 113. Six honours awarded during the British administration are listed, but unfortunately omitted is the MBE awarded to Charalambous Middleton for his exceptional work during the disastrous 1956 forest fires. The cause of these fires is attributed only to 'incendiarism in connection with the EOKA resistance movement', which is misleading: the forest officers serving in Paphos Forest at the time were in no doubt that many were caused by plain carelessness by members of the British security forces. The area burned was also increased by delaying the attendance of fire-fighting villagers and restricting their numbers.

For a book published in 1987 it is somewhat weak on events in forestry and Cyprus generally since independence in 1960, to which only an 'Epilogue' is devoted. One wonders why 'the de facto division of the Island' is ascribed to 1964, why the 1974 invasion by Turkey is termed an 'intervention', why the so-called 'Turkish Federated State of Kibris' is mentioned without the qualification that it is a regime recognised only by Turkey, and why the map in Figure 10 shows the northern part of Cyprus as the 'Area occupied by Turkish Cypriots', ignoring the presence of Turkish armed forces and Turkish settlers.

A better awareness of contemporary Cyprus would surely have caused the author to report the massive investments being undertaken in reservoir construction and irrigation water distribution which are transforming lowland agriculture. In the conditions of Cyprus these would have been impossible without the protection of the forested catchments. Such knowledge might also have made the author qualify his statement that 'Cyprus is unsuited to large barrages'.
These faults notwithstanding, the book is a well researched record of the work of the Cyprus Forest Department during the British occupation, and not least of the outstanding work of the heads of the Department. It is not invidious to make special mention of Unwin, Waterer and Chapman, whose particular aptitudes and abilities followed each other in the most fortuitous but favourable succession. The book has a Foreward by Chapman and it is indeed fortunate it was published before his death in February 1988.

To make a tribute inadequately is perhaps worse than making no tribute at all. The author has succeeded in making this book a well documented, readable and fascinating account of the progress of forestry under the British in Cyprus, but above all it is a fitting tribute to the men who laboured to create a highly successful Forest Department, the fine traditions of which are maintained to this day.

D. Brierton
Back numbers of COMMONWEALTH FORESTRY REVIEW (formerly Empire Forestry Journal) are available on 35mm microfilm for the years 1922–1983 in preparation 1984–86. Complete set (17 reels) £476 plus postage. Quotations for particular years on request — minimum order £28.

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Our Advertisers are helping the Association keep down the cost of the _Review_. Please let them see some response by members to the services they have on offer.
Her Majesty the Queen, with His Royal Highness, The Duke of Edinburgh, presenting the first Queens Award for Forestry to Dr. John W. Turnbull in Melbourne on 29th April 1988
Temperate Trees

Given half a chance, temperate woodland will colonise open ground, existing woodland will tolerate indifferent management and compensate for management abuse. In the Eastern States of North America, marginal farmland is once again becoming modestly profitable broadleaved woodland. The European coniferous forest belt has experienced extensive felling over the last 50 years but if one discounts the impact of ‘acid rain’ and the 1976 drought, the forests now have a bigger stocking and larger annual increment than they had in the late 1930's. The increase in the thriftiness of the forest has been helped by the removal of slow growing over-mature specimens and their replacement by a thrusting younger generation.

Tropical Trees

Whilst each particular area of tropical forest has its own distribution of species, its local climatic characteristics and hence sweeping generalisations tend to be less valid than with the temperate forests, very few examples come to mind of where man’s impact has not had an adverse effect on the forest’s welfare. The differences between the temperate and tropical forest stem from the increased strength of tropical sunlight, the resultant higher soil temperature giving an increased rate of mobilisation of organic matter, less surface litter and poorer distribution of organic matter within the surface soil layers. The warmer air is less dense, the clouds over the tropics reach greater altitudes; strong rising currents of air maintain ice and hail in circulation allowing further accumulations so that when rain finally reaches the ground, the size of individual drops is that much larger. Hence, in the tropics the soil does not enjoy a protective layer of decaying vegetation, the rainfall is intense and causes physical damage on impact and the subsequent lateral flow of water results in sheet erosion. When the sun shines, the bare soil is baked to an inhospitable ‘brick’.

Those who would manage the tropical forest must first ensure the welfare of the forest soil. If one of the objectives of management is the growing and harvesting of timber in perpetuity, the soil must be protected against undue exposure to rain and sun. Clear felling and the burning of the lop and top may be acceptable in Northern Europe but not in West Africa. Many of the commercially attractive tropical trees are strong light demanders — Obeche (Triplochiton scleroxylon), white afara (Terminalia superba) and teak (Tectona grandis) — all of which show success as plantation species. But by definition, a plantation of light demanders needs to be even-aged with all the trees reaching economic maturity at the same time, hence the eventual clear-felling and its problems can be foreseen at establishment. The light demanders do have their role where destroyed forests need replacing, but some forest research needs directing towards the identification and propagation of shade tolerant trees with commercial attributes.

Points of View

Once upon a time we built a road, some thirty odd miles along the eastern foothills of Mount Cameroon. The current lava flow from the volcano was trundling its way towards the only road to the coast. Our road metal was being quarried from the aerial deposition
of breccia which, as potsherds indicated, had fallen on some earlier habitation. The six small hunting communities encountered en route relied upon the forest for all their requirements and their various backgrounds were manifest in the lack of a common African tongue. They did have a common interest that the road should come their way and where this was not practicable, they moved the village accordingly. Our goal was the timber of the tropical rain forest with overseas markets in the west and local outlets for sawn-timber. Our interests coincided with those of the Forest Department, who collected revenue from us to provide the bulk of the national income, also with the forest people who enjoyed the royalties and the chance to embrace 'civilisation'. The forest had over 100 species which reached commercial size but the 35 species which were marketable represented 90% of the upper canopy and in places 80% of the canopy was of one species—Obeche (*Triplochiton scleroxylon*). In juxtaposition with trees of 2.5 m diameter were the suppressed remains of palms which could be found as early colonisers on more recent mud-flows around the mountain. Concentrations of Sapele (*Entandrophragma cylindricum*) at the termination of a recent lava flow had not yet reached the minimum size which the Forest Department would accept for felling; some of the forest was still in its infancy. On the north of the mountain at Boviongo, in the fringe of woodland dominated by ilomba (*Pycnanthus angolense*), we tripped over a concrete post. Conversation with the elderly village chief—in pidgin and German—showed that our road was approaching an area previously colonised from the north west of the mountain at Debundscha in the 1900's and the ilomba was on the site of an erstwhile tomato farm. Ilomba had been the species used for cleaving to provide the carraboard cladding on the editor's hut. Sitting here one evening, reading a six month old copy of the *Review*, with lightning strikes terminating the lives of dominant trees in the locality at the rate of 20 a minute, a distraught family arrived. Their young boy had inadvertently been shot by their village hunter with his muzzle loaded flint-lock. Splints and a sling coped with the arm broken after falling from a tree but other wounds needed more skilled attention. What would previously have been a six day walk was
accomplished in 80 minutes in the jeep, reaching Tiko via Ekona where the lava steamed a mile short of the road. The road and hospital resulted from the activities of the ‘exploiters’ of the rain forest, the timber industry and the sometime maligned commercial interests whose profits derived from the harvesting of oil palm, cocoa and bananas.

Volcanoes may be uncomfortable neighbours but they do provide fertile soils. Mount Cameroon (4,400 m) will not be satisfied until it has joined the islands of Bioko (Fernando Po), Principe and Sao Tomé to the mainland and consolidated its hold through Kumba up to Wum. Now, at least our road offers some chance of evacuation and has already provided access for the taking of photographs — credited to Korup.

In our case we were intrepid explorers bringing enlightenment to the dark areas of the globe and utilising the fruits of the earth for the benefit of mankind before they were irrevocably lost beneath the clinker of the next eruption. But in today’s climate we were raping the earth’s last remaining haven of wildlife where the mature specimens had a unique genetic inheritance deserving dissemination throughout the forest. The older generation may be growing too slowly, it may be over-mature, over weight and suffering from butt rot but whilst it cuts out some light from the thrusting generation below, it also offers shade and shelter for the foundations within which the youngsters are rooted.

Churchill Travelling Fellowships

The ‘chance of a lifetime’ for 1989 offers the opportunity of up to 100 awards a year for citizens of the UK. The closing date for the 1989 awards is the 17 October, ‘88. Those short-listed will be asked to give more details of their proposed projects in December, those called for interview in January will know the results by February. The same opportunities will arise again next year, but it is not until the June Review that the classifications for consideration will be known. Of the 11 categories for 1989, the following could involve members:- Open project for The Netherlands, Explorers and expedition leaders, Woodland and forest—their maintenance and renewal, lastly, Deer management and control.

Further details and application forms from The Winston Churchill Memorial Trust, 15 Queen’s Gate Terrace, London SW7 5PR.

General Foods ‘World Food Prize’

The Association has been invited to submit a nomination for a candidate who has “...personally made a significant and applied contribution to the quantity, quality or availability of food.” Our nomination needs to be sent before 31 December ‘88. Further details are available from Winrock International, Petit Jean Mountain, Morrilton, Arkansas 72110, USA.

Better Environment Awards for Industry 1988

Four awards are made annually, sponsored by the Environment Foundation, Department of the Environment(UK) and Shell UK Ltd. The winning idea for the Appropriate Technology Award last year was the Nomad Solar Kiln, featured in the March ‘87 Review. Congratulations to Bob Plumtre with the OFI, to the Cambridge Glasshouse Co. Ltd., and the Intermediate Technology Development Group Ltd. The other categories include ‘The Environmental Management Award, The Green Product Award and the Pollution Abatement Technology Award. Details are available from The Royal Society of Arts, 8 John Adam St., London WC2N 6EZ.
Changing Tropical Forests: Historical Perspectives on Today's Challenges in Asia, Australasia and Oceania

IUFRO's Tropical Forest History Working Group (S6.07.01) met at the Australian National University in Canberra, 16-18 May 1988. The workshop was the first of three planned by the group to cover the tropical regions.

The workshop was attended by 45 scientists and historians who presented papers concerning Australia, Bangladesh, Fiji, Hawaii, India, Indonesia, Mauritius, Papua New Guinea, Phillipines, Thailand and Sarawak. They provided economic, ecological, forestry, historical, human geographical, and geomorphological perspectives and covered various periods to the present.

The meeting was concerned largely with deforestation and degradation in various countries. However the meeting recognised the critical importance of reforestation and afforestation for the future. It was thought that the group might focus some of its attention on the history of reforestation and plantation enterprises in future.

The proceedings of the conference are being edited by Dr John Dargavel, Centre for Resource and Environmental Studies, Australian National University, GPO Box 4, Canberra 2601, Australia. They should be published by the end of the year.

The 2nd Queen's Award for Forestry

It is planned for the 2nd Queen's Award for Forestry to be presented on 20 September, 1989 during the XIIIth. Commonwealth Forestry Conference at Rotorua, 18-29 September, 1989. Nominations are being accepted from all Commonwealth countries but should be channelled through the Association's Local Honorary Secretaries; members of Governing Council or Regional Representatives. The National short-lists will be forwarded to the Secretary for consideration by the Executive Committee. Short-lists should reach the Secretary by 15th January, 1989. A nomination form is enclosed with this June issue and further copies are available on request. The candidates should be in mid-career having made their mark in some aspect of forestry or forest utilisation; they should be sufficiently articulate to communicate their experience to the benefit of the community and be prepared to report to the Association at the conclusion of their travelling scholarship.

The Annual Meeting, 1988

This year's venue was The Royal Forest of Dean, in Gloucestershire, UK. Some 50 members and friends were welcomed by our President to the formal meeting at Speech House, the focal point of the forest where the Verderers who oversee the forest have been holding their quarterly meetings for some hundreds of years. The Senior Verderer of the Forest is Dr. Cyril Hart who made us most welcome and presented His Grace with his recently published book on the forest.

Our Speaker was Mr. Ronnie Williams, Secretary of Timber Growers UK who entertained the meeting with an illustrative account of recent developments in the timber processing industries in the UK with their implications for the continued welfare of the forest.

The forest is some 9,800 ha of which a maximum of 4,450 ha may be enclosed at any one time, the physical location of the enclosures taking account of the establishment programme. At least 42% of the forest has to be managed as broadleaved woodland, the species favoured are oak, ash, beech and sweet chestnut. The choice of conifer takes account of the soils, Douglas fir on the sand-stones, Norway spruce, European larch and Corsican pine being used as the soils become more alkaline. The annual sustained yield
from the forest is about 65,000 m³ with just over half being sawlogs with the bulk of the remainder being of lower quality. Conservation influences the management of the forest, some areas are managed with the agreement of the RSPB (Royal Society for the Protection of Birds); 400 ha of oak will be grown on an extended rotation specifically for the benefit of the associated wild life. Some commercial timber orientated members convinced each other that the variety of bird life appeared to be far greater in the 48m tall Douglas fir rather than in the similarly aged oak at half the height. Our immediate Forestry Commission host was John Everard, the Deputy Surveyor — the man in charge of the Dean. His Conservator, whose responsibilities also covered lands to the west. John Fletcher was joined by Roger Busby who managed to wave the flag for Tree Aid. Other Commission staff, David Craze, Ted Jury, David Mackey and John Anderson guided the visitors through the aspects of the forest that were their respective responsibilities. The forest clothes the valley sides eroded by the streams running into the boundary rivers of the Wye and the Severn from the modestly elevated plateau. There is a tradition of free mining for those born in the parish of St. Briavels; coal-mining having been practiced since Roman times. Attractive areas now forested include the slag heaps of previous centuries. Forest management caters for the million visitors who come each year. The construction of Mallards Pike Lake was funded from opencast coal mining and in its setting of introduced spruce, larch and fir is managed by the local Lions Club for water activities, excluding fishing. Forest management also has to contend with sheep grazing, theoretically limited to the unenclosed areas. Sheep impose their own
speed restriction on the forest roads where they enjoy the warmth of the asphalt and carry out their phlegmatic assessment of the passing motorist. Members were refreshed with a welcome cup of tea at the Royal Forest of Dean Golf Club. Dinner at The Speech House was concluded with a showing of ODA’s award winning film of tree planting in Nepal and also the video of Her Majesty’s presenting the first Queen’s Award for Forestry.

The first visit on the second day of the meeting was to Formwood Ltd., at Coleford. Managing Director Gavin Barlas and Sales Director Alan Jones showed us how the staff of some 200 transformed an annual in-put of 8,000 T of equal proportions of small (2"–19" dia.) larch and beech into their two main products, 2.5M garden table tops and 400,000 m$^2$ of ‘Formalux’, the latter finding major outlets as an open cell ceiling system used in a wide range of commercial building including hotels, shopping arcades and at Heathrow. After welcome refreshment, the Forestry Commission staff introduced the party to a variety of maturing conifers. Gerald Smith from Walford Sawmills demonstrated the merits of a fine felled parcel of Douglas fir which will encourage trade members wanting logs over 30m long to attend the Commission’s subsequent auctions. Following a light lunch at Littledean, and an attractive journey along single-track lanes past Flaxley Abbey to Huntley, we were welcomed to Huntley Forest Products by Roger Worgan. Some of the timbers being used in the making of gates and garden sheds originated in the Dean but it was noticed that some of the furniture was made in iroko (Chlorophora excelsa). Our last visit was to the nurseries of Woodland Improvement where Dr. Hart, who had been instrumental in organising much of our programme,
welcomed us and introduced the General Manager, Barry Wellington. Between the 15ha home nursery and a further 18ha at Newent, some 6M seedlings are raised annually. Part of the annual 3M transplanting programme was in progress using a Super Prefer. Although we had enjoyed fine weather for our meeting, the nursery had taken the precaution of providing us with an undercover demonstration. This included samples of young beech with a healthy root system in ‘rootrainers’. These trees were distributed to those members with opportunities for planting. Our President was able to add the beech to the young oak which Dr. Hart had presented; the acorn coming from an oak planted by Her Majesty at Speech House in 1957. The meeting closed with tea, kindly hosted by Dr. Hart, at the Forest Gate Hotel.

We had already expressed our appreciation to our various hosts, to those of the Commission who had to fly off to other commitments but at lunch, our Chairman, Roger Bradley had bade farewell to Bruce Gourlay who has been a staunch supporter of the Association during his terms of office with the Canadian High Commission. On a domestic note, we were delighted to have John Pitt with us and hope his wife Peggy makes a speedy recovery. Another of our past staff was visited on the way back from the Dean, Judy Bromiley sends her good wishes to you all and is hoping to attend next year’s AGM. This is provisionally arranged for the 25 and 26 May, 1989, to be based by the kind invitation of our President at Drumlanrig Castle in Dumfriesshire.

**Outstanding CFA dates for 1988**

The ‘outstanding dates’ which have already taken place include the January meeting at the Canadian High Commission, the Albury Reception in April and the AGM mentioned above. The dates of future events which are at present outstanding are:-

**UK**  
September 27:–Reception and dinner at New Zealand House. It is hoped that many members will be able to take part in what is planned as a major Timber Trade function, launching the further funding for the Queen’s Award for Forestry (Further details from the Secretary).

**UK**  
September 29:–Morning meeting of the Executive at the Forestry Commission’s Offices at Lyndhurst. Members and spouses welcome to join for a rustic lunch and mini-tour in The New Forest.

Australia November 12:–Meeting and lunch at noon at the Commercial Club, Albury, NSW. (Details from Vice-Chairman Bob Newman, PO Box 802, Albury, 2640.

**CAIFA**

The *Canada-Africa International Forestry Association* was officially registered in British Columbia on the 4 August, 1987. The initiative came from Africans working in British Columbia following the United Nations Association conference on African forestry in March 1987. There is now an office at 102–375 Whittier Avenue, Victoria, B.C. The CAIFA Executive, with encouragement from the Canadian International Development Agency (CIDA), financed the attendance of a representative to the African NGO’s forestry workshop held in Nairobi in September 1987. Funding has been obtained from the ‘Canada Job Development Training Program’. One of the staff has attended a fact finding CIDA visit to Nepal and another to a CIDA assessment project to Sri Lanka. The intention is that funds raised in Canada shall be put to constructive forestry use to
help mitigate the effects of vegetation loss in Africa. Further details may be obtained from the Program Manager Ilidy Szabo.

Agriculture and Forest Science School, Bangor, North Wales

Professor Laurence Roche is heading the 25 staff in the recently formed school which integrates the interests of Agriculture and Forestry. The Centre for Arid Zone Studies is established within the framework of the School. The tropical emphasis attracts substantial numbers of overseas students, the 100 students in the 1987/88 year represented 36 different nationalities.

Australian Forest History Society

The first national conference on Australia’s forest history that was held in Canberra 9–11 May, 1988, resolved to form the Australian Forest History Society. The aim of the society is to advance historical understanding of human interaction with Australian forest and woodland environments. Membership is open on application to any person or organization supportive of the aim of the society. It is intended that the Society be free of, and be seen to be free of, any particular interest group.

It was decided to organise the society as an information and contact network in a fairly ‘low-key’ way at least for an initial period. Rather than elect a full-scale committee and adopt a formal constitution, it was decided to appoint four convenors and nominate contact persons in each state and territory. There is to be no membership fee initially. A more formal structure could be considered in two or three years time if it is found to be needed.

The convenors were made responsible for producing a newsletter and for convening a future conference. The newsletter will be produced twice a year as the main communication between members. It will be distributed to libraries, public land management agencies, professional associations, interest groups, forest industries, etc. It will include material such as: research in progress, notices of publications and meetings, grants available and book reviews.

Further details of Application Form and local contacts in the various Australian States may be obtained from Dr. Kevin Frawley, Dept. of Geography, Australian Defence Force Academy, Campbel ACT 2600.

Commonwealth Foundation Fellowships

The CFA is one of 44 organisations invited to submit nominations for the Annual Fellowships awarded by the Commonwealth Foundation. In the first year of the Award, Tony Cannon came to London from Tasmania, the next year we had our nomination accepted but his programme change prevented participation. Last year, Graham Tulley travelled to India as part of his award. The nominations for 1989 can be accepted from the following countries:– Brunei, Cyprus, Ghana, Grenada, Kenya, Lesotho, Malaysia, Maldives, Mauritius, Nauru, New Zealand, St. Kitts, St. Lucia, St. Vincent, Solomon Islands, Sri Lanka, Swaziland, Trinidad and Tobago, Tuvalu, UK, Uganda, Vanuatu, Zambia and Zimbabwe.

The CFA can make two nominations to the Commonwealth Foundation by 9 November, 1988, hence CV’s of aspiring candidates should reach the Oxford Office by 7/11/88. Nominees should be within the 30 to 50 age group, should have the interest and capability to act as ambassadors of the Commonwealth, should have interests outside their professional sphere and they should be free to take part in the April ‘89 programme. The Fellowships include the cost of travel to London for the first two weeks.
and the subsequent two weeks in East Africa. There are 12 Fellowships for 1989. The Fellows are expected to produce a report on their programme on their return home and a further report in June 1990, outlining specific activities they have undertaken to promote the Commonwealth. Proposed Award winners would be notified by 9/12/88 with confirmation of acceptance required by 6/1/89.

The Albury—Wodonga Bicentennial Forestry Conference

The Australian Forest Development Institute has sent the following letter to the Heads of Governments as the concluding statement of the conference held from 25 April to 1 May, 1988

"The World’s forests are being destroyed and mismanaged on a massive scale. Participants at the International Bicentennial Forestry Conference at Albury NSW Australia are concerned to see the sustainable forest management of natural forests and a substantial increase in tree planting across the world to meet the needs of future generations.

Time is not on our side, nations can no longer take supplies of timber for granted, nor can they regard their forests as a source of unlimited wealth tapped at will to meet short term gain.

Leaders are asked to ensure that their nation’s policy on forests and tree planting will meet future needs”.

This positive message of concern comes very clearly from Forestry experts from more than twenty countries from the five continents of the world focusing on Australian forestry in the next 100 years.

Prominent national participants have indicated their full support by attaching their names as signatories to this letter.

"The forest is not something we inherit from our fathers, it is something we borrow from our children”.

Yours respectfully,
Conference Chairman Ross Flanery; Conference Secretary Bob Newman
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NEWS OF MEMBERS AND FRIENDS

Dr. Joseph O. Adegbehin, recently of the Savanna Forestry Research Station, Samaru and even more recently at the Rivers State University at Port Harcourt is at present with the Department of Extension Agronomy (Forestry) at Ahmadu Bello University, Zaria, Nigeria.

J. B. Ball may now be contacted in his capacity as Project Manager, FAO GCP/ SUD/033/NET, UNDP Khartoum, c/o UN Palais de Nations, 1211 Geneva 10, Switzerland.

Dr. John Bathgate has been appointed head of the School of Forestry and Timber Processing at Waiairiki Polytechnic, Rotorua. The new School of Forestry and T.P. has its origins in the Forestry Training Centre and the Timber Industry Training Centre. Dr. Bathgate was Principal of the former since 1985 and Acting Principal of the latter for the last year. Details of courses may be obtained from The Forestry Training Centre, PO Box 943, Rotorua, New Zealand.

Arend Jan van Bodegom is working in Peru based at Cuzco, the old Inca capital. The community forest project is financed by the Dutch government and executed by FAO. Similar schemes are being proposed for Ecuador, Bolivia and, where Arend previously worked, in Colombia.

Duncan Campell has been appointed the Director of the Countryside Commission for Scotland. He served for 27 years with the Forestry Commission and was head of their Environment Branch. He graduated from Edinburgh with a first class honours in Forestry and also has a diploma in landscape design from Newcastle University.

J. H. Casey has been appointed Project Co-ordinator for Borno State on the World Bank Afforestation Programme for Northern Nigeria. He may be contacted via ‘South Borno’, c/o ADPLA, 27 Dover Street, London W1X 3PA.

Roger Courtney has been appointed the Director of the Building Research Establishment (UK). In addition to his earlier work with BRE, he spent five years with the Cabinet Office becoming Deputy Head of the Science and Technology Secretariat. He returned to BRE as Deputy Director to Dr. Rex Watson who now retires. Dr. Watson was awarded the CB in 1987. Prior to joining the BRE he had been the Director of the Chemical Defence Establishment at Porton Down.

Derek Earl has been appointed Forestry Advisor for the EEC in Uganda to assist the Forestry Department which is in the newly created Ministry of Environment Protection. The work entails the identification and application of suitable management systems to the 1.3 M ha of natural forest reserve to sustain the production of much needed timber and other forest produce and enhance the habitat for flora and fauna. The Project will liaise closely with ‘the World Bank Program for the rehabilitation of the Uganda Forest Department’ and attempt to reconcile the various objectives of agencies, organisations and individuals interested in the conservation of the natural forest.

Dr. Ian Gibson is wished a happy retirement. He now wishes to conclude his consultancy work on tropical forest tree diseases. It is hoped that some of his own trees at Ninfield in East Sussex, survived the October ‘87 wind blow.
**Dr. Christopher Gill** is the incoming Director of TRADA having joined TRADA in 1984 as Deputy Director of Research and Development. The retiring Director, John Sunley, was presented with a pair of elm book-ends by the President of the Timber Trade’s Federation, Richard Carr, at the TTF’s Annual General Meeting.

**Dr. Andrew Gordon** runs his own seed business, Forestart at Shrewsbury, England. He was previously with Economic Forestry Group and the UK Forestry Commission. He is President of the committee of forest nurseries in the EEC. He has been appointed a director of Ronaash Ltd., distributors of the Canadian Rootrainer tree-propagation system; the Australian distributors will need to be alert to the problems of leaking joeys.

**Tony Grayburn** of Tokoroa has been elected President of New Zealand Forest Owners Association. He succeeds Lin Stoddart whose concluding message to members was that Forestry had the potential to support over 100,000 jobs (in New Zealand) and that export earning — essentially from *Pinus radiata* — was realising an annual figure of well over $5 billion.

**Arne Heineman** is working for ICRAF in Kisumu near Lake Victoria. He had 30 months in Ethiopia working for UNIDO before his degree at Oxford and a short spell at home in the Netherlands.

**Tecwyn Jones** OBE, Deputy Director of the Overseas Development Natural Resources Institute, has been appointed an Honorary Professor of the University of Wales in the Department of Zoology at Cardiff. Professor Jones joined ODA in 1974 following over 20 years in Africa. He was in charge of the West African Timber Borer Research Unit in Ghana and Nigeria. His work included a period as Director of the East African Agriculture and Forest Research Organisation in Kenya, Uganda and Tanzania. He edited the *East African Agricultural and Forestry Journal*.

**Sten Karlberg**, President of Silviconsult Ltd., Flädie Kyrkväg, S-237 00 Bjarred (Lund) Sweden announces the formation of Silviconsult (Africa) Ltd. The Managing Director is Francis Odoom, a Ghanian, forestry graduate of Aberdeen — PO Box 929, Takoradi, Ghana.

**Frank Knight’s address** is now PO Box 253, Famona, Bulaway, Zimbabwe.

**Alan C. Oliver** has been appointed as Timber Preservation Manager with Pandrol International Ltd. The company specialises in the supply of rail fastenings to railways world wide. For many years Mr. Oliver was Senior Lecturer on Biodeterioration and Wood Preservation at the Buckinghamshire College in High Wycombe UK. He will be providing technical service support for the development of a new concept of timber preservation for railway sleepers using TIMBERSHIELD fused borate rods. Associated with this product is a vibration analysis testing machine (*Panlogger*) which can determine the interior condition of sleepers *in situ*. The address of Pandrol International Ltd., is 1 Vincent Square, London SW1P 2PN.

**Rt. Hon. Geoffrey Palmer**, Deputy Prime Minister of New Zealand will open the Royal Show in the UK on the 4 July. The Royal Show is organised by the Royal Agricultural Society of England at the National Agricultural Centre, Stoneleigh, Warwickshire. The Show will continue until the 7 July; it has its own Forestry and Sawmilling section where well established trees offer welcome shade. Any members wearing CFA ties will be offered hospitality by the Secretary.
D. K. Paul has retired from his FAO post as Senior Forestry Officer in the Investment Centre and is offering consultancy advice from his address at 10 Gordon Terrace, Edinburgh EH16 5QW.

Dr. P. K. Ramachandran Nair, a Council member of ICRAF, has a two year leave of absence from the Global Project on Agroforestry Systems Inventory, whilst he will be Professor of Agroforestry at the University of Florida.

Nicholas Read has been appointed the Research Adviser to the National Farmers’ Union of England and Wales.

Dr. Alexander Robertson has been appointed an Honorary Lecturer to the University College of North Wales. This will enable him to continue his introductions to the media for student foresters. His (Canadian Forest Service) video camera was in action during the Association’s Forest of Dean meeting. Sandy visited the UK en route between Newfoundland and Iceland where Sigurdur Blöndal and his forest staff are co-operating with the Canadians in assessing climatic influences on the forest; Harry McCoughey of Queen’s University, Kingston, Ontario will be assisting with the geological aspects of the young volcanic soils.

Having a spare day between collecting his Degree at Oxford and travelling to the Association’s AGM, Sandy welcomed the opportunity of seeing a forestry consultant (the Secretary) in operation, running his business of Forest Advisory Services. This entailed early morning nursery work, deliveries, actual planting of a small shelter belt, marking a thinning in a softwood plantation, entertaining two young lady planning officers to a pub lunch and helping them assess the potential problems on two woodland sites. Another site appreciation involved the landscaping of a proposed factory with a final visit in the early evening to survey the trees and woodland on a £2M golf course project.

Alison Sayers has been appointed to the Consultancy Division of the Economic Forestry Group PLC. Her previous experience in Sri Lanka will help complement Jack Easton’s expertise in developing the Group’s agro-forestry and community forestry schemes. During her time with the Timber Growers Organisation and subsequently Timber Growers UK, in her capacity as Assistant Secretary, she enjoyed a spell as editor of Timber Grower, she serviced the Land Use and Environment Committee and most recently, represented woodland owners on the committee dealing with the wind blow problems in the south and east of England.


Dr. Filemon Torres, who played a significant role in establishing ICRAF’s agroforestry research networks during his 8 years up until June 1987, is now Deputy Director-General of Centro Internacional de Agricultura Tropical (CIAT) in Cali, Colombia.

Peter Wood, who has been working with ICRAF in Nairobi since 1983, has returned to the Oxford Forestry Institute where he will work on a part-time basis. This will enable him to undertake some freelance consultancy work.
Roger Worgan, of James Joiner and Sons Ltd., Cinderford, Gloucestershire, was one of the hosts for the second afternoon of the Association's May meeting. He recently became an honorary life member of the British Timber Merchants' Association (England and Wales). He was presented with the certificate by another James Joiner man, John Freeman, President of the Western and Southern Counties BTMA.

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Publications, Forest Research Station, Alice Holt Lodge, Wrecclesham, Farnham, Surrey GU10 4LH, UK.

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OBITUARIES

Richard Cuthbert Barnard

Dick Barnard, who died on 3rd April, 1988 in Taunton, Somerset, in his 80th year, was a distinguished former member of the Malayan Forest Service which he joined in 1931.

He was born in 1908 at Taiping, Perak, his father being a civil engineer with the Malay railways. The family had a long association with Malaya, his uncle being a member of the Department of Forestry and his cousin a member of the Police.

Dick was at Clifton College and then Emmanuel College, Cambridge, where he graduated in forestry in 1930 as one of the last graduates before the Department of Forestry closed. He was attached to Hertford College during his one-year course at the Imperial Forestry Institute, Oxford before returning to Malaya.

His early stations as District Forest Officer were in the important districts of Tapah, Peak and Jasin, Malacca. In 1940 he became Timber Purchase Officer supplying timber to the rapidly expanding military needs in the country. He was a member of the Federated Malay States Volunteer Force and as a prisoner of war of the Japanese army survived the infamous horrors of the railway construction in Thailand.

After the war he was posted again to Tabah and for a while acted as State Forest Officer, Perak. His keen and natural interest in silviculture and a dislike of administration resulted appropriately in his appointment in 1947 as Silviculturist at the Forest Research Institute, Kepong where he steadfastly remained until his early retirement in 1956 shortly before Independence.

Dick's achievements during his many years as silviculturist are monumental. He provided the main drive and inspiration for the research of the Malayan Uniform System of natural regeneration management for the lowland forests, which were subjected post-war to the introduction of intensive mechanical logging. His main interest, however, was undoubtedly in artificial regeneration. He introduced the polythene tube for the raising of potted seedlings and adapted John Innes compost making and potting mixture to Malayan conditions. Following the international Eucalyptus study tour in Australia in 1952, on which he produced an excellent report, he was responsible for a large screening research programme of potential eucalypt species for the Malayan rain forest. This was later extended to tropical pines.

His major long-term contributions to scientific literature of tropical forest management are the early version of the 'Manual of Malayan Silviculture for Inland Forests' which was published in 1954 as Research Pamphlet No 14 and an article on the 'Silviculture in the tropical rain forest of Western Nigeria compared with Malayan methods'. (This journal 1955, XXXIV, 355–368 and Malayan Forester 1955, XVIII, 173–190).

Dick retired early both for family reasons and to enjoy the building up of a most successful private venture on the growing of eucalypts, primarily Eucalyptus gunnii, for cut foliage at Bovey Travey, Devon. The business was sold in 1968 to a younger ex-member of the Sabah Forest Service and still flourishes.

Dick married in 1935. Peggy, who was also a very keen gardener, died in 1987. They were a most charming, friendly and hospitable couple, who enjoyed a rural life to the full. They will be sorely missed. They are survived by a daughter and a son and four grandchildren to all of whom we extend our deepest sympathy.

J.W-S.
Moshe (Milan) Kolar — 1919–1988

Moshe Kolar was born in 1919 in Yugoslavia. He read forestry at the University of Zagreb and graduated in 1946 from the Federal Institute of Technology (E.T.H.) in Zurich, Switzerland. In 1949 he immigrated to Israel, joined the Forestry Department of the Jewish National Fund. In 1952 he was called to organize the division of forest management. Kolar started to apply sound forestry practices to all phases of forestry, carried out periodical inventories of the growing stock, prepared management plans, and volume tables, introduced silvicultural thinnings of plantations and pioneered the utilization of home grown wood by establishing departmental sawmills.

In 1962 Kolar was appointed Deputy Director of the Forestry Department. He emphasized long-term planning in management, forest policy, forest economics and international collaboration. Since timber production in Israel can be a paying proposition only on the best sites he pioneered the application of the concept of multiple use, whereby each forest provides many benefits, produces wood, serves for recreation, protects the soil, provides shelter for wildlife and regulated the water supply, with management priorities varying according to site conditions. Mr. Moshe Kolar represented Israel at World Forestry Congresses and was Israeli representative to the FAO General Committee and Europan Forestry Commission. He promoted the professional level of the forestry staff and organized international forestry seminars in Israel. He was the author of numerous professional publications.

His death on January 11, 1988 is an irreparable loss to all who knew him and leaves a void in Israeli and international forestry circles.

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FORTHCOMING INTERNATIONAL DATES

3/7/88-9/7/88 CANADA, Vancouver. 1st International Conference on Classification, Phylogeny and Natural History of Scolytidae. Ref: D. E. Bright, Biosystemics Research Centre, Canada Agriculture, K. W. Neatby Building, Ottawa, Ontario, Canada K1A OCa.


15/9/88-17/9/88 CANADA, Quebec City. ‘Silvilog 88’. Forest equipment Demo’ and conference. Ref: A. A. Rotherham, WS, CP & PA, 1155, Metcalfe Street, S2300, Montreal, Quebec, Canada H3B 4T6.

13/ 9/88-16/ 9/88  SCOTLAND, Edinburgh. Remote Sensing (IGARSS '88 plus RSS '88) (Tutorial day on update on microwave technology on 12 Sept.) Suggested subjects include ‘Forest Inventory and Assessment’ and ‘Mapping with Radar Data’. Ref: J. Young, Dept of Geography, University of Edinburgh, Drummond St., Edinburgh EH8 9XP, Scotland.


19/ 9/88–22/ 9/88  USA, Seattle. Timber Engineering '88. Ref: Dr. R. Y. Itani, Dept. CEE, Washington State University, Pullman, WA 99164–2914, USA.


27/ 9/88–  ENGLAND, London. CFA Reception at New Zealand House. Ref: Secretary CFA, OFI, South Parks Road, Oxford OX1 3RB.

29/ 9/88–  ENGLAND, Lyndhurst. CFA New Forest Visit. Ref: Secretary CFA, OFI, South Parks Rd, Oxford. OX1 3RB.


2/10/88– 8/10/88  SWITZERLAND, Interlaken. Air Pollution and Forest Decline, IUFRO. Ref: W. Baltensweiler, Institut für Phytomedizin, Clausiusstrasse 21, Ch-8092 Zürich, Switzerland.


18/10/88–22/10/88  INDONESIA, Jakarta. Forestry and Woodworking Exhibition. Ref: PT Pamerindo Buana Abadi, c/o N. West, Overseas Exhibition Services, 11 Manchester Square, London W1M 5AB.

00/11/88–00/11/88  CUBA, Havana, Forestry Congress and Symposium on Agriculture. Ref: Secretary Congreso Forestal, Palacio de las Convenciones, Apartado 16046, La Habana, Cuba.

12/11/88–00/00/00  AUSTRALIA, Albury, NSW. CFA Meeting and lunch 12 Noon, Commercial Club. Ref: R. L. Newman, PO Box 802 Albury, 2640 or Tel. 0604 11266.


27/ 6/89– 1/ 7/89 MALAYSIA, Kuala Lumpur, Woodwork 89 (Forestry, Timber Processing, Woodworking Exhib.) Ref: Randle Theobald, O.E.S.Ltd. 11 Manchester Square, London W1M 5AB, UK.

23/ 7/89–26/ 7/89 USA, Boston. “Meeting Global Wildland Fire Challenges” (Joint USA/Canada Fire Services) Ref: G. O. Tokle, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269, USA.


5/ 8/90–19/ 8/90 CANADA, Montreal, XIXth IUFRO World Congress.

AROUND THE WORLD

CANADA

The Canadian Forestry Service-Maritimes, located in Fredericton, New Brunswick, Canada, has recently relocated to its new world-class research facilities in the Hugh John Flemming Forestry Centre. To mark the occasion, the federal forestry establishment hosted a week-long (May 2–7) open house which attracted nearly 12,000 visitors and a variety of dignitaries including Canadian Prime Minister Brian Mulroney and his wife, Mila.

The CFS-Maritimes is responsible primarily for forestry research, development, and technology transfer programmes in the Maritime provinces. They are also involved in various national and international programmes including ENFOR, acid rain monitoring, forest insect and disease surveys.

With their move to the Hugh John Flemming Forestry Centre, the CFS-Maritimes is now located in the same state-of-the-art complex as the provincial government’s department of natural resources, the University of New Brunswick’s industrial forestry research group, and the Maritime Forest Ranger School. Having these two levels of government plus a significant academic community and various other organizations and associations under one common roof has created a centre of forestry excellence unique not only to Canada but perhaps all of North America.

A copy of a CFS leaflet on their work in the Maritimes may be requested from Dr. John C. Lees, CFS-Maritimes, Box 4000, Fredericton, New Brunswick, E3B 5P7, Canada.

CHINA

Members may be interested in the figures offered in the FAO ‘Tigerpaper’ Vol XIV, No 3 ‘87 in the article by Qin Gengzhu, Director of Foreign Affairs in the Ministry of Forests at Beijing.

Semi arid areas in the north west, north and north east cover nearly 4M km$^2$ (41% of the country. Deserts have increased by 3.9Mha over the last 25 years and now occupy 30% (1.3M km$^2$). Problems of soil and water erosion are aggravated by severe dust storms. Conservation of existing forests and the creation of new forests became imperative. Between 1978 and 1985 6.05Mha of shelter belts were planted and 890,000 ha of mountain land were closed to encourage natural regeneration. Village schemes resulted in the planting of 1,500M trees, the road authorities planted 50,000 km, the railway authorities established 14,000 km of shelter belt, 22 airports were made responsible for improving their local vegetation. Tree planting helped to bring 8Mha of farmland into production and a further 1.7Mha of pasture. The Maowusu and Kerqin deserts have been changed from areas without grass to respective forest cover of 15.8% and 13%. The planting target for the period from 1986–96 is to reforest 6.37Mha, to create 0.17Mha of plantation be aerial seeding and enclose 9.45Mha of mountain for natural regeneration. The effect of this planting would have been to raise the percentage of land under trees from the 4% of 1978 to 7.7%.

The coastal regions of China suffer from typhoons sweeping in off the sea; planting of 3.33Mha of shelter belt will increase the protection being afforded.

China provides the home for some 14% of the world’s 2,400 different animals and 30,000 plants. The area of mountain landscape under protection rose from 2.6Mha in 1952 to 23.8Mha in 1986. Nature Reserves have increased in area from the 8.06Mha in
1983 to 19.33Mha in 1986 with the intention that 2.5% of the land will be in this category by 2000.

Forest enterprises produce an annual timber production of 34Mm³ which is 65% of the national output (60Mm³ in 1985). Sawn timber output has increased from 3.44Mm³ in 1950 to 15.9Mm³ in 1985; wood panel products have risen from 16,900 m³ in 1951 to 1.65Mm³ in 1985.

Other forest based industries produce rosin, tannin, shellac, alcohol, furfural, yeast, gallnut, tannic acid, active carbon, paperboard, adhesives and cork, giving in total, increases of 36 times the production 30 years ago. Figures for minor forests produce include annual outputs of 2,400T of honey, 160T of edible black fungus, 1,650T of edible wild herbs, 119,999T of walnuts, 65,000T of chestnuts, 0.35MT of fresh dates and a similar quantity of tung oil-seeds. Tea-oil from Camellia on 4Mha provides 0.5MT of oilseed which in turn provides some localities with 30–50% of their vegetable oil requirement.

The whole emphasis of the national policy encourages the general public to become involved with tree planting, since 1982 some 200M people have been involved in planting 1,000M trees.

EQUADOR

An estimate in 1971 considered that some 30Mha of well stocked natural tropical forest still remained. Some 3Mha of undisturbed forest was easily accessible in the north west of the country. By 1977 almost 0.5Mha of land had been occupied by farmers only 5% of whom had title to the land. The record of wood received by sawmills in 1976 was 42,000 to 56,000 m³, this was up to 2% of the timber which had been cut for land clearance. The rapid colonisation of land following the construction of roads for the petroleum industry is endangering the sustained supply of logs for the timber industry. Reforestation schemes have an important role to play for the protection of water catchment areas and their associated reservoirs (Schmidt. Unasylva 39).

HONDURAS

In the month of May 1988, Honduran Forest Development Corporation (COHDEFOR) and the Canadian International Development Agency (CIDA) embarked on a new phase of collaborative action in the Republic of Honduras. The project, entitled the Hardwood Forest Development Project, has the following as its objectives: 1) the improved forest management and utilization of the hardwood forests and 2) the improved standard of living of the forest villagers who live in the periphery of the forest.

The project is composed of two principle components — institutional support directed at assisting COHDEFOR in improving its level and quality of forest management and watershed management to improve the land use in pilot watersheds. The watershed management phase will be implemented jointly with the regional offices of the Secretario de Recursos Naturales and the Instituto Nacional Agrario. The project will be conducted within the Hardwoods Forest Region which covers all of the Departments of Colon and Atlantida, some 1.1Mha. The main office is in La Ceiba with sub-offices in the communities of Tela, Sonaguera, and Bonito Oriental.

The activities foreseen for the institutional support phase include forest inventories, silviculture, reforestation with small farmers, protection of the natural forest, personnel training, and the development of management plans for the better use of the resource.
An example of the type of activity which will be undertaken is promotion of small woodlots to supply domestic wood needs of fuelwood and building materials of the communities in the Aguan Valley.

The watershed management phase will focus on improving the land use within selected pilot watersheds. Activities will include the preparation of a land use plan, soil surveys, extension program in improved farming and soil conservation practices, land titling for small landholders, and the conservation and protection of the existing forest resource. Tentatively, the first working area will be the watershed of Rio Cangrejal near La Ceiba. This work will not only benefit the residents of the watershed but also the population of the city of La Ceiba too.

The CIDA has collaborated for many years with COHDEFOR in the development of the forestry sector. The present project is five years in duration at an estimated cost of $CDN 15.5M of which the CIDA is donating $CDN 11.5M to cover operating costs, material and equipment purchases, and the salaries and benefits of Canadian experts. Further information on the project may be obtained from John Roper, Principal Advisor CIDA-COHDEFOR Forestry Program, Apartado Postal 102-c, Tegucigalpa, Honduras, Central America.

SUDAN

Two approaches to the De Forestation problem in Sudan.

The following report was prepared for the *Review* by Philip Vernon, now working for Care International in the Sudan.

Famine in Africa is once again front page news. Readers of this, as foresters, will be well aware of the link between environmental degradation and food shortages. They may therefore be interested in two differing approaches to re-afforestation being practised in Sudan.

The Eastern Region of Sudan borders with Ethiopia. During the past twenty-five years a steady stream of political refugees has crossed this border to settle in Sudan. In recent years this refugee population has been swelled enormously by famine refugees.

The Sudanese Government has housed the refugees in camps and settlements throughout the region. At each site the sudden increase in local population has resulted in an equally sudden increase in environmental degradation, as trees were cut for land clearance, firewood, and building materials. This compounded an existing situation whereby the powerful mechanised farmers were ruthlessly increasing the area of land under tillage at the expense of the traditional and rather fragile bush fallow/nomadic grazing system.

In 1983 funds were made available by USAID for a reafforestation project in the area. A large international charity organisation, CARE, took on the task of running the project. The Eastern Region Reafforestation Project’s aims were to establish two large nurseries and several thousand acres of plantations. These would employ large numbers of refugee and Sudanese labourers, giving the local economy a cash boost. At the same time, an extension programme would attempt to persuade both large and small farmers of the long-term wisdom of incorporating some tree planting into their fields, in which yields have dropped by as much as 60% during the last thirty years.

The two nurseries were established in 1983, and provided seedlings for outplanting in the 1984 rainy season. Each nursery produced about ½ million seedlings per year over the following five years. These were plastic potted stock, using various soil mixtures experimentally. Species used were almost all local Acacias.
Site preparation in the plantations involved cross-ploughing at 3×4 metres, after which the furrow intersections were improved, using spades to create a micro-catchment utilising the run-off water from 12 sq m. Planting began as soon as the ground was wet down to about 20cm depth, and was followed immediately by weeding (spot and line). The soil is a deeply cracking dark clay, and a final operation of filling in the cracks around each seedling took place from November to December.

Survival rates in these plantations varied greatly, from virtually nil in years of low rain to as high as 85% in some places.

Because of the immense difficulties of organising these operations it was inevitable that most project energy was channeled into them, to the detriment of extension activities. However, some success was achieved, after much hard work on an uphill task, in persuading large-scale farmers to sow tree seeds in shelterbelt configurations; several smaller farmers did the same on their own land. A major part of extension activities at first was the free distribution of trees for household compound planting, but this tailed off somewhat when staff decided to begin charging nominal prices for the seedlings. Gradually, too, it became clear that, no matter how long they had already spent in Sudan, the refugees felt no real association with the land and it was therefore difficult to motivate them to take an interest in its long-term productivity.

An important factor to remember in the context of this article is that ERRP employed large numbers of labourers — up to 1400 at the height of the planting season — and that the main means of motivation was the payment of cash wages for work done.

Across the Sudan to the West however, a very different project was started by CARE in 1985. Based in El Obeid, the capital of Kordofan Region, the Kordofan Agroforestry Extension Project grew out of the famine relief programme CARE had been involved in. CARE's policy where possible is to phase in development programmes once the initial relief programme begins to phase out. This enables them to make use of the best of the staff from the relief programme, as well as the valuable information they have gained concerning the area and its problems during the relief operations.

KAEP, funded by Canadian International Development Agency, works in the Gum Belt, where farmers have traditionally grown *Acacia senegal*, from which Gum Arabic is tapped, as part of their crop rotation. This system is vulnerable in times of extended drought, when many trees die. At the same time the natural regeneration process stops because there is not enough rain either to allow trees to produce good seed crops nor to germinate and feed any seeds which are produced.

KAEP encourages villages to set up small communal nurseries producing *A. senegal* seedlings, with the aim of rehabilitating the land now, and also of providing the means, on a self-sustaining basis, to do the same after any further drought that may occur. These nurseries are village owned, run by a men's and a women's committee, who employ a nurseryman on a profit-sharing basis. KAEP provides training for the nurseryman and regular technical back-up, along with the polythene bags in which the seedlings are grown. Water is free, since nursery sites are all adjacent to village wateryards, and a simple waste water collection system has been designed. This provides free water for the nursery and eliminates the health hazard of standing water and mud around the taps.

An unexpected spin-off has been that villagers have used the nursery area to produce vegetables on a year-round basis. This not only improves the nutritional status of their diet but also provides the revenue needed to ensure the self-sustainability of the nurseries. If not for the vegetables it seems likely that the seedlings would have to be priced at a level too high for the average farmer to afford, just to ensure that sufficient funds would be generated with which to maintain the nursery.

The only wage-earners paid directly by KAEP, apart from project staff themselves,
are the small team of plumbers and masons who construct the waste water system at the beginning of each nursery’s life. If all goes well there will be no need to carry out any major repairs to the water system for many years, by which time the nursery should have sufficient funds and sufficient management experience to deal with the matter.

The fundamental difference between the two projects is clear. In ERRP we have a project that uses wages paid out of a finite source outside Sudan to motivate people to plant trees to prevent further degradation of their land. KAEP, on the other hand, exploits the existing relationship between local farmers and *Acacia senegal* to motivate those farmers into participating in the production of seedlings without wages: indeed the farmers actually buy the seedlings from their own nurseries in order to ensure that the nurseries will sustain themselves and live on long after the project finishes in 1990.

It would be wrong to convey the impression that one of these two projects is doing things the right, and one the wrong way. They are two approaches developed in very different circumstances to deal with the problem of de-forestation as manifested in two distant localities. One factor common to both is the emphasis on working hand in hand with the Forest Department, right from the original project proposal, through in-project training provided for seconded FD staff, to the point when both project activities and assets are handed over to the FD at the end of the project’s life.

This writer has worked on both projects, first as a volunteer through Voluntary Service Overseas (VSO), then as a contract forester. VSO offers foresters of all ages the opportunity to experience a very different living and working environment from that they are used to in UK. Volunteers are paid roughly at the same level as their local counterparts, which allows them to bridge easily the social gap that often grows between the highly paid expatriates who normally staff projects and agencies in the Third World and the local people.

UGANDA

In 1964, the forest area was assessed at 1,693,833 ha. By 1987, this figure had been reduced to 677,533 ha. These figures emerged during the official opening of the Uganda Forestry Association on Tree Planting Day (16 October, 1987). Dr. John Aluma of Makerere University, is the chairman for the Association. The objectives of this NGO will be:— to raise funds, to increase public awareness of the non timber benefits of forests, to encourage increased public co-operation in protecting the forest and in using its produce wisely, to institute forest research and implement its findings and to liaise with government and other land users to obtain the optional management and utilization of the forest’s resources.
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BRITISH FORESTRY — AN INTERNATIONAL PERSPECTIVE

By John Campbell O.B.E.,* 

SUMMARY

The demands of an increasing population on the world’s natural forest, places at risk
the industrial and environmental benefits which have been taken for granted by past
generations. Increased re-planting and more intensive forest management is a matter
of some urgency requiring the attention of world leaders. The EEC, being one of the
largest importing blocks in the world for timber and wood products, with Britain by
far the largest consumer, Britain must increase its self-sufficiency, and offer support
for developing nations, to ensure long term wood supply programmes to meet future
needs. The wood resource created in Britain by planting over the last 50 years has
resulted in a complete transformation in the UK forest industry. During the last 5
years with an investment approaching US$2BN a highly efficient wood processing
industry competitive by world standards has evolved, raising self-sufficiency from
12% to 16% with the prospect of a further increase with sawnwood rising to 26% by
the year 2005. Is this an example to other nations of what can be achieved by a
consistent long term Government forestry policy?

RÉSUMÉ

Les exigences d’une population multipliante sur la forêt naturelle du monde mettent
en péril les avantages industriels et environnementaux que les générations
antécédentes s’y ont été habitués. Les chefs mondiaux doivent s’occuper des cas
urgents de reboisement augmenté et l’aménagement forestier plus intensif. La CEE
étant un des blocs importateurs les plus grands du monde de bois d’œuvre et de
produits de bois, avec la Grande-Bretagne de loin la consommatrice la plus grande,
la Grande-Bretagne doit augmenter son indépendance et donner son appui aux pays
eau de développement pour assurer des programmes à long terme
d’approvisionnement de bois pour pourvoir aux besoins futurs. La ressource en bois
créée en Grande-Bretagne par plantation dans les 50 ans qui viennent de s’écouler a
mené à une transformation totale dans la filière bois du Royaume-Uni. Pendant les 5
ans qui viennent de s’écouler une industrie forte efficace de conversion du bois qui
fait concurrence dans les marchés mondiaux a évolué, avec un investissement de près
de US $2BN, augmentant l’indépendance de 12% à 16% avec la perspective d’une
augmentation supplémentaire, avec les sciages augmentant à 26% par l’an 2005.
Est-ce un exemple aux autres nations de ce qu’on peut accomplir par une politique
forestière gouvernementale conséquente à long terme?

RESUMEN

Las demandas de una población creciente en el recurso forestal mundial, pone en
peligro los beneficios industriales y ambientales de los que se han aprovechado las
generaciones pasadas. El aumento en la reforestación y el manejo forestal más
intensivo, es un aspecto de cierta urgencia que requiere la atención de ciertos líderes
mundo. La Gran Bretaña que es sin duda el mayor consumidor de la Comunidad Económica Europea, CEE, que es uno de los mayores bloques importadores de madera y productos forestales en el mundo, debe incrementar su
autosuficiencia y ofrecer apoyo a las naciones en desarrollo con el fin de asegurar

* Group Chief Executive Economic Forestry Group
programs para abastecimiento de madera a largo plazo que cumplan con las necesidades futuras. El recurso de madera creado en Gran Bretaña a través de plantaciones en los últimos 50 años, ha resultado en una completa transformación en la industria forestal británica. Durante los últimos cinco años, con una inversión que se aproxima a los US$2 billones, se ha desarrollado una industria de procesamiento de madera altamente eficiente y competitiva para los estándares mundiales, aumentando la autosuficiencia del 12% al 16%, con una perspectiva de aumento aún mayor, con un incremento del 26% en madera aserrada para el año 2005. ¿Es este un ejemplo para otras naciones de lo que puede alcanzarse con una consistente política forestal gubernamental a largo plazo?

World Issues

It was impossible for anyone to be truly isolated from the effects of the unprecedented change resulting from uncertain oil prices and the world recession in the seventies. The management of change will therefore remain a major task facing individuals, organisations and Governments during the next decade. Change in science, technology and attitudes towards conservation and the environment, will have an increasing political impact in the ‘Green Vote’. In meeting this challenge we must face the inevitable reality of the growing interdependence of today’s world. We expect a great deal from those among the younger generation who will soon carry the major political responsibility. We hope that their insistence in saving this world for people will overcome bureaucratic regulations and constraints and political differences. Substantial progress in developing countries will be required if we are to make the change to a reasonably stable world sustaining over ten billion people by the next century (2025).

The world conservation strategy, with its aim of maintaining essential ecological processes, preserving genetic diversity and ensuring sustainable utilisation of species and eco systems, has had an accumulative effect on global issues. The incidence of ‘acid rain’ caused by windblown sulphur dioxide and emissions from vehicles, damaging forests and eliminating fish life from some lakes and waterways, has been regarded by many scientists as the world’s most serious problem requiring world cooperation and global change in future industrialisation. The use of pesticides, herbicides, and fungicides, is a further global issue. Similarly the concern about toxic waste has been focused on the disposal of radioactive nuclear material. No day passes without some reference in the media on these very issues and general apprehension across the world is accelerating and reaching all countries. Whether you are a politician, a businessman, a scientist, an economist, a trade unionist, or indeed a forester like myself, we must all share a common apprehension for the times in which we live. As consumers of the world’s major forest resources on a massive scale all of us in the developed world inevitably bear the greater responsibility for the future of mankind.

Future World Demand for Wood

World wood removals in 1983 exceeded some 3,000 Mm³. Fuel wood accounted for just over half of the total, with the remainder being industrial wood converted into lumber, plywood, paper and other products. The developing world consumes 75% of all fuel wood while the developed nations take 85% of all industrial wood removals although the vast majority of wood harvested from natural forests is consumed in the country of origin. Wood in the form of logs, lumber and other timber products is one of the most important primary commodities in the international trade market exceeding $100 billion per annum. A number of authoritative forecasts including those provided by the U.N.
Food and Agricultural Organisation (FAO) suggest that by the year 2000 wood demand would be either approaching or slightly exceeding the level of maximum sustainable removals and conclude that there will be considerable strains on supplies. Softwoods will be in short supply and there will be a swing to hardwoods. Tropical deforestation mainly resulting from shifting cultivation and rising industrial wood needs in the developed nations will limit the volume of tropical hardwoods available to the world market. Indonesia has more than 10% of the world's tropical forest — only Brazil has more. Environmental groups here claim that every year there is a loss of about 1Mha. Major importers such as Western Europe and Japan will be especially vulnerable in these circumstances. A number of major uncertainties about future demand fog the crystal ball. When, if ever, will the paperless office arrive and cause a major structural change in the pattern of consumption of pulp and paper products. Will this be offset by the development of the chemical uses of wood? What effect will new developments in housing construction have on demand for solid wood products? How rapidly will the one billion citizens of the Peoples' Republic of China increase their appetite for industrial wood imports? What will happen to the level of Japanese imports currently accounting for 16% of all forest product imports? The FAO European Forestry Commission predicts that the consumption of timber products will increase at a rate of between 0.5% and 3% per annum to the year 2000 with the strongest growth in the paper and board sectors and with Europe remaining a large net importer. It is for experts in these fields to fit the answers to these questions into future demand scenarios for the different product groups and markets, but whatever the result, you might agree that in spite of rising self-sufficiency in the UK to possibly 26% we will still fall so far short of total demand that the changes in any of these areas will have little impact on the UK production from existing plantations. Britain remains a large market for exporters.

Prospects for World Wood Supplies
The prospects for future industrial wood supplies will be just as uncertain as those for demand. Assessing the extent of potentially extractable industrial wood supplies, is fraught with difficulties, especially when it comes to quantifying such factors as forest decline, accessibility, location of forests relative to markets and transport routes, the steepness of mountain slopes, the quality of the wood resources contained in forests and the withdrawal of areas from production for reasons of wilderness and conservation. There will probably be no major new sources of wood supplies available from Northern hemisphere natural temperate forests in the foreseeable future. About 21% of the world's forest resource is coniferous, supplying about 70% of world industrial timber. The USSR possess 57% of all closed conifer forests in the world and although theoretically it could sustain a considerable increase in removals, difficulties in extraction and lack of infrastructure and internal demand make it unlikely that supplies from the distant forests of Siberia will substantially increase in the near future. The USA with 10% of the world's closed forests has had significant areas of publicly owned forests taken out of productive use and classified as wilderness areas and is increasingly dependent on timber supplies from the Southern forests. The same could possibly happen in Canada and other countries. There is, however, a prospect of new supplies coming on stream from the maturing fast-growing plantations that thrive in the warmer regions of the Southern hemisphere. The annual increment of these plantations may be ten-times that of natural forests. This could lead to a diversification of world wood supplies involving countries like New Zealand, Chile, Brazil and South Africa which have invested heavily in plantations in the last few decades. Last year Chile exported
both pulpwood and woodchips to Sweden at low cost. However, it is still questionable whether these plantations will be able to provide wood of sufficient quality and quantity to satisfy the needs of the world market and whether the investment will be available in some politically high risk areas. A higher level of protection of forests against fire, pests and diseases and windthrow will be vital if removals are not to make a significant impact on long term world supplies. Time is not on our side. Industrial countries can no longer take the supplies of timber from the world's natural forests for granted and developing nations can no longer regard their forests as a source of unlimited wealth, tapped at will to meet short-term cash needs, without considerable risk to the ecological benefits which they also provide. I therefore want to say something that dwarfs party politics and matches the problems of nuclear disarmament and even hunger, and that is 'tree planting'. Each year throughout the world 12M hectares of forest are cleared for agriculture and fuel wood and only 1M hectares are being replanted. I want to see more tree planting across the world and I want to see forest management and not forest exploitation. We must therefore seek agreement with the politicians, the wood industry, and the environmentalists on tree planting. We all want more of it but there is little agreement on how it is to be achieved and how we attract investment funds from the public and private sectors. I understand all of the feelings and anxieties involved but the fundamental question for us all wherever we live is how we can sustain both the industrial and environmental benefits which our forests provide for future generations.

Implications for Europe and Britain

The EEC is the largest importer of timber and wood products in the world with a timber trade deficit exceeding 18.00 M ECU/annum, of which Great Britain is by far the largest importer, importing 90% of its US$9bn pa consumption of our total annual import costs of forest products. Sadly British agriculture is probably at its lowest ebb since the Second World War. Having made dramatic improvements in production, based on the application of sound research and increased mechanisation, and some say a unique and cosy relationship with the Government, the position has now changed beyond all recognition. The chill winds of the free market will surely continue to blow until the problems of reducing the huge, crippling costs of food surpluses can be seen to be under control. The Common Agricultural Policy (CAP) which now absorbs over three quarters of the total EEC budget of US$40bn has proved hopelessly unwieldy in practice by seeking to impose common agricultural systems across different social structures and amassing huge food surpluses. Whatever models and assumptions we care to use for the UK we find that approximately one million hectares of land needs to come out of food production over the next ten years and tree planting is now recognised as being one of the few major alternatives for the use of this land on such a scale. In 1985 the EEC Commission set up a forestry advisory committee and published a forestry action plan for discussion. In spite of the political differences regarding the reform of CAP there is still increasing pressure to bring in some forestry initiatives to expand tree planting. With the agreement of the 'Single' Act and the one 'internal market' targeted for 1992, the decision processes may well take less time than they have done in the past, therefore trade associations like those in the timber trade ignore Brussels at their peril. It is important to know what you want from the EEC, to build up your contacts and influence in Brussels, to ensure that you do not wake up after five years and find there is a directive or regulation which can be quite damaging to your interests.

A recent study by the Centre Technique de l'Industrie du Bois (CTIB) concludes that there are no common standards covering dimensions, moisture content quality or preservation treatment.
TRADA is well placed to limit technical barriers or restrictions on the use of timber through the harmonisation of codes and standards, creating a larger market place for timber products against substitute materials.

U.K. Government Policy

After an exhaustive review of forestry in 1980–81 the case for forestry was accepted based on reducing the high cost of net imports, exceeding US$7bn per annum, 6.1% of Britain’s import bill, the relatively low area of land under forest (less than 10%), the potential for tree growth in UK (being twice that for the natural conifer belt), and the provision of essential jobs in rural areas. Forestry already employs over 43,000 people directly with a further 500,000 in industries using imported timber and forest products. An expansion of forestry also provides the opportunity to develop a permanent wealth creating industry competitive by world standards. The Forestry Act 1981 committed Government to an expansion of Britain’s forests and also enabled the Minister to sell state forest-lands for the first time. The planting target of 30,000 ha was set, which would be predominately the responsibility of the private sector. With the encouragement of grants and fiscal incentives, since that time new planting has risen over 20% from 20,300 ha to 24,700 ha and the proportion planted by the private sector has risen from 43% to 79%. More recently in attempting to reduce the huge costs of farm surpluses by taking land out of farming the government intends to introduce the Farm Woodland Scheme in October 1988. There is additional grant aid of up to US$300 per ha per annum with a further target of 36,000 ha of farm woodlands to be planted over the next 3 years. The procedures which exist to secure grant support through the Forestry Commission require private foresters to pay due regard to environmental impact studies which require good forest design and good forest management, particularly with regard to the landscape, wildlife conservation, protection of water resources etc. Following the introduction of the 1981 Act the Forestry Commission was instructed to become largely self financing and has sought to raise US$175M from forest land disposals by 1989. Something like US$170M has been raised to date compared with a total value of US$2bn–US$3bn and an estimated return of 3.1%. This has not presented a problem but it has resulted in the privatisation of the Forestry Commission becoming a political issue, a debate which has been further encouraged by the successful privatisation of the New Zealand forest service. This is not something that I personally support but I do see that there may be a once and for all opportunity for rationalisation of forest lands between the State and Private sectors to create large efficient forests by world standards. Deer do not mind whether they are grazing in State forests or in private sector forests. If the private sector is to have the opportunity to attract the large institutional funds or unitised funds into forestry it is only likely to happen in Britain if the financial yield appears competitive and government decides that a much higher level of rationalisation involving something like 20% of total assets is acceptable.

Britain’s Forest Resource and Supply of Industrial Roundwood

Most of Britain’s remaining natural forest resources were essentially felled during the First World War which led to the establishment of the Forestry Commission as a result of the Forestry Act in 1919, since when the UK has followed an aggressive policy of afforestation. Today, Great Britain has a total productive woodland area of about 2.1M ha of which 1.5M ha are comprised of coniferous plantations and the remainder is broadleaved forest. Virtually all forests in Britain are ‘man made’ and can be classified as
'intensively managed'. The emergence of private forestry companies commenced in the late 1950's providing a forestry establishment and management service to private investors, looking to take advantage of Government Grants and tax incentives to invest in forestry. Today private forests in Britain account for about 1.2M ha, 57% of the total forest estate. The Forestry Commission has some 890,000 ha or about 57% of the total coniferous forests in Britain.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Age distribution of coniferous forests (1,000's ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in Years</td>
<td>10</td>
</tr>
<tr>
<td>Private Forestry Commission</td>
<td>120</td>
</tr>
<tr>
<td>Total</td>
<td>190</td>
</tr>
<tr>
<td>Percentage</td>
<td>13</td>
</tr>
</tbody>
</table>

The supply and end use of coniferous roundwood from British forests has been increasing steadily over the last two decades, increasing from a total roundwood cut of 2.8Mm³ in 1977 to a forecast of almost 4.9Mm³ in 1987. Two thirds of coniferous forests are productive exceeding 20 years old. The latest forecast prepared jointly by the Forestry Commission and the private woodland owners reflects anticipated available volumes as standing timber. Allowing for logging and mensuration losses, EFG estimate that the volume of logs over the next twenty years available to the industry in Britain compared with the current forecast demand in 1987 is shown in Appendix 1 Table 2.

**Forecast Coniferous Roundwood Available to the Industry in Britain**

The volume of coniferous roundwood forest to become available for industry will double in the next 15–20 years. Ownership of Britain's forests is shared equally between the State and private sectors. Productive softwood forests extending to 1.2M ha is predominantly Spruce and Pine located in Scotland (0.8M ha) of which 66% is managed by the Forestry Commission. The types of ownership within the private sector vary from individuals and co-owners to institutions. The latter will continue to dominate the market for established plantations particularly in the upland areas where the higher financial yields are more likely. UK pension funds started investing in forestry in 1975 and there are now about forty funds directly involved and each year two or three new funds make their first investment. The total value of investment in forestry by pension funds in the UK has been approximately US$50M over the last 3 years and their forestry investment normally represents 2–3% of their total portfolio although for certain funds it has been up to 5%. With the largest area of coniferous plantations in the control of the Forestry Commission, the larger pension funds are unlikely to become committed in the UK unless there is a policy of selling off some of the larger productive State forests and the investment yields appear competitive.
British Small Diameter Coniferous Roundwood Based Industry

When discussing sawmilling, the pulping and reconstituted wood based panel industries play an important role in the overall viability of the sawmills by providing markets for residues. The pulping and particle board industries reached a state in the late 1970’s and early 1980’s carrying high energy costs where they were uncompetitive with imported products and the softwood based industries collapsed. Since 1982 the industry has undergone a major transformation and the British product valued at over US$1bn annually can now maintain a competitive edge by world standards. Our Swedish, Finnish, German and Austrian friends have played a major role in the establishment of these new industries. In the last five years major investments have been made amounting to US$1000M with a further US$700M planned. Projects include

(a) a new 200,000 T pa pulp and LWC paper mill at Irvine in Ayrshire to be built by the Kymenne Corporation of Finland, an investment of US$370M. The mill is scheduled for completion in 1989.
(b) United Paper Mills’ new 200,000 T pa pulp and newsprint mill at Shotton in North Wales with a second newsprint machine planned to be installed by 1990.
(c) Expansion of particle board manufacture by Kronospan in Wales and at Egger in Hexham.
(d) A new OSB mill by Highland Forest Products near Inverness.
(e) Increased production of MDF and particle board by Caberboard at Cowie and Irvine.
(f) Expansion and modernisation of sawmilling at numerous sites.

The above developments have now reached a point where the forecast available volumes of small diameter roundwood and sawmill residues in Britain will be almost fully utilised for the next ten years. A recent Forestry Commission/Statement concluded — “there now appears to be adequate capacity installed and planned to absorb all the sawlogs and small roundwood coming forward to the turn of the century”. Apart from recycling waste papers any further expansion will therefore result in the increased utilisation of broadleaved species. This has already started in the particle board industry. Thus the prospects for the sale of sawmill residues appear to be encouraging for the next decade. If further plans for expansion currently being rumoured go ahead, then there could be a deficit in coniferous roundwood requiring either roundwood imports or an increased usage of broadleaved roundwood in the industry of some 500,000 m³ over bark per annum in the early 1990’s.

Markets — Appendix 2

The volumes of softwood lumber arrivals into the UK rose by 9% in 1987 with Canada raising its market share from 21–26%. The planned increase in processor capacity over the next 20 years will not significantly alter Britain’s position as a small producer in the European forest products markets. It will however allow British mills freedom to compete aggressively with the large Canadian and Scandinavian surpluses particularly where quality customer service and technological innovation together with distance to the market can turn the balance to advantage. It is difficult to aggregate Britain’s total consumption of the full range of processed forest products, but it is currently in excess of US$9 bn, excluding goods manufactured from forest products such as furniture. During most of the past decade Britain’s overall consumption of forest products has been estimated as being equivalent of 38 Mm³ of wood of which only around 3.9 Mm³ has
APPENDIX 1

Table 2
Forecast Coniferous Roundwood available to the Industry in Britain in 1,000 m³ ob/a

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sawlogs</td>
<td>2740</td>
<td>2550</td>
<td>3045</td>
<td>3885</td>
<td>4875</td>
</tr>
<tr>
<td>Small Dia</td>
<td>2170</td>
<td>2305</td>
<td>2685</td>
<td>3130</td>
<td>3515</td>
</tr>
<tr>
<td>Total</td>
<td>4910</td>
<td>4855</td>
<td>5730</td>
<td>7015</td>
<td>8390</td>
</tr>
</tbody>
</table>

APPENDIX 2

Table 3-2
U.K. Softwood Sawntimber Consumption, Supply and End Use
Part 1 U.K. Consumption of Softwood Sawntimber and Self-Sufficiency (1000 m³)

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scotland</td>
<td>340</td>
<td>407</td>
<td>537</td>
<td>476</td>
<td>576</td>
<td>578</td>
</tr>
<tr>
<td>England and Wales</td>
<td>492</td>
<td>562</td>
<td>690</td>
<td>702</td>
<td>829</td>
<td>758</td>
</tr>
<tr>
<td>Total</td>
<td>832</td>
<td>969</td>
<td>1227</td>
<td>1178</td>
<td>1405</td>
<td>1336</td>
</tr>
<tr>
<td>Imports</td>
<td>9832</td>
<td>6328</td>
<td>7071</td>
<td>6678</td>
<td>6420</td>
<td>7000</td>
</tr>
<tr>
<td>Exports</td>
<td>36</td>
<td>30</td>
<td>24</td>
<td>21</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Apparent Consumption</td>
<td>10628</td>
<td>7267</td>
<td>8274</td>
<td>7835</td>
<td>7805</td>
<td>8316</td>
</tr>
<tr>
<td>Level of Self-sufficiency %</td>
<td>7.83</td>
<td>13.33</td>
<td>14.83</td>
<td>15.04</td>
<td>18.00</td>
<td>16.07</td>
</tr>
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</table>

Part 2 U.K. Consumption of Softwood Sawntimber by End Use Sector (1000 m³)

<table>
<thead>
<tr>
<th>End Use Sector</th>
<th>Imported</th>
<th>1982 British</th>
<th>Total</th>
<th>Average 2002–2006</th>
<th>1982 %</th>
<th>2002–06 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>4700</td>
<td>120</td>
<td>4820</td>
<td>5595</td>
<td>885</td>
<td>6480</td>
</tr>
<tr>
<td>Packaging</td>
<td>650</td>
<td>440</td>
<td>1090</td>
<td>535</td>
<td>640</td>
<td>1175</td>
</tr>
<tr>
<td>Fencing</td>
<td>480</td>
<td>340</td>
<td>820</td>
<td>350</td>
<td>680</td>
<td>1030</td>
</tr>
<tr>
<td>Sawn Mining Timbers</td>
<td>0</td>
<td>130</td>
<td>130</td>
<td>0</td>
<td>115</td>
<td>115</td>
</tr>
<tr>
<td>Others</td>
<td>410</td>
<td>70</td>
<td>480</td>
<td>380</td>
<td>120</td>
<td>500</td>
</tr>
<tr>
<td>Total</td>
<td>6240</td>
<td>1100</td>
<td>7340</td>
<td>6860</td>
<td>2440</td>
<td>9300</td>
</tr>
<tr>
<td>British Supply %</td>
<td>15.0</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
come from domestic resources. The post 1984 expansion of the processing industry has
resulted in domestic products pushing their share of total consumption up to 12.1%,
valued at over US$700M annually and the planned expansion in Britain’s processing
capacity in the period up to 2000 could result in a 16–18% market share being achieved.
The overall picture indicates continued expansion in British demand to 2000 within the 4
main forest product segments.

1. British consumption of paper and carton board is forecast to rise by 30–55%,
   although Britain starts from a low production base in paper using domestic wood
   pulp. The future rate of expansion will be in line with northern hemisphere
trends.

2. British consumption of domestic wood pulp including waste paper is set to rise by
   60–100% over the period. Again this is starting from a low production base and
   going faster than for Europe as a whole.

3. Britain’s demand for panel products including plywood will grow by 70–80% over
   the period at a slightly slower rate than for western Europe with particleboard
   and especially OSB taking an increasing share of Britain’s market. Currently
   domestic production is about 1Mm³ meeting 39% of the market.

4. British demand for sawnwood will increase by 30–50%.

Additional growth above the 1.5 MT of sawnwood currently consumed representing a
major opportunity for domestic mills. In the sawnwood market it has been found that
with good presentation, well sawn and dried to specified moisture levels the timber is
readily sold in the construction market. Table 3.2 sets out the consumption and supply of
sawntimber in the UK for the period from 1973–1986 and for consumption of supply
forecasts for the early 2000’s. Since 1973 British softwood sawn timber has doubled its
share of the market from 8–16% in 1986. In spite of an increase in domestic production
increasing to 1.3 Mm³ in 1987 there has been a slight fall in self sufficiency. By the early
2000’s British softwoods are expected to provide 26% of the consumption of softwood
sawntimber in the UK. The penetration of British sawntimber into the market sector
previously the domain of imported softwood has been increasing in the last decade.
Growth in the UK market is expected to be modest at less than 1% per annum average.
In 1982 British softwood supplied 120,000 m³ of sawntimber into the construction
market sector. By 2002–2006 this is expected to have increased to nearly 900,000 m³
which will correspond to 26% of the forecast market for construction graded
sawntimber. With the slow anticipated growth of the market it is not anticipated that the
increasing available volumes of sawn product will be absorbed in the other traditional
sectors as other low cost producers in the EEC will compete and satisfy the market.
Sawmillers in the UK are gearing their production facilities to serving the construction
industry and generally have found good acceptance of their product. In addition we now
have added value products based on British softwoods appearing on the market such as
mechanical stress graded material, dressed profile siding and panel boards, extra long
length structural battens, pressure treated fencing and structural material, dressed CLS
lumber etc. With the competitive sawlog supply over the next 5 years and likely longer,
companies are looking seriously at the opportunities of upgrading adding value to their
produce by making mouldings, architraves, laminated products etc.

When considering the wood based industry in Britain it is important to remember that
these industries are located within one of the major markets of the world and in general
do not depend on export markets and usually sell a significant proportion of their
production within a reasonable proximity to the mill. This has been a key factor in the
development of the current structure of the British sawmilling industry although the
**Table 4**
Structure of British Sawmilling Industry in 1986.

<table>
<thead>
<tr>
<th>Capacity Log intake (m³ ob/annum)</th>
<th>No. of Mills</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 — 2,500</td>
<td>183</td>
</tr>
<tr>
<td>2,500 — 5,000</td>
<td>105</td>
</tr>
<tr>
<td>5,000 — 10,000</td>
<td>63</td>
</tr>
<tr>
<td>+ 10,000</td>
<td>74</td>
</tr>
<tr>
<td>Total</td>
<td>425</td>
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</tbody>
</table>

total number of sawmills has been declining the industry is still dominated by small family mills (table 4). In the last 10 years some rationalisation of the industry has started with the emergence of lead groups. With the forecast supply of sawlogs projected to be some 300,000 m³ over bark per annum below the current capacity and further larger scale mills to be announced over the next couple of years, we anticipate an accelerated rationalisation with the emergence of a more efficient and competitive industry. The announcement late last year of the merger of A. & R. Brownlie Limited and Thomas Smith and Sons (Kirkoswald) Limited, two of the leading larger British sawmilling groups, exemplifies this trend. This merger will give the group a combined log capacity approaching 600,000 m³ ob per annum distributed between mills in Scotland and Wales. This corresponds to about 25% of the British sawlog supply. The larger mills have expanded, increasing capacities of individual mills to between 30,000 m³ ob per annum and 100,000 m³ per annum of log input. Features of the rationalisation taking place include not only size, but the following:-

(a) Improved product dimension tolerances and presentation, which has been instrumental in increased penetration of the construction market in competition with imported lumber.

(b) Increased product development catering for specialised markets on either a local basis or supplying specific dimensional requirements not readily met from the imported suppliers.

(c) Increased customer services with prompt delivery developing strong customer loyalty.

(d) Increased utilisation of sawmilling lines designed specifically for given sawlog specifications and products, such as small log circular double slabbers and gang slashers (cant edges) for the production of mining timbers, pallet boards and fencing materials from lower volume logs.

(e) Kilning is relatively new in the industry with Brownlie and TSK again leading in this area. A quote from the *TTJ* December 87 Michelle Rogers “I recently spent 4 days travelling around Scotland; the vastness of the forest and the level of commitment and enthusiasm shown in the country sawmills makes it difficult to imagine British timber not continuing to be an increasing success story”.

**Conclusions**

British forest products are set to increase their share of the rapidly growing home market over the next 12 years. Self sufficiency in total forest products is set to rise from 12% to possibly 18% by the year 2000, in spite of a 30% rise in demand for paper and board over
the same period. In 1989 Britain will have 5 large integrated pulp and paper mills and 7 major panel board plants, most of them using the latest technology. They will be able to compete aggressively against importers in market sectors where quality, technological innovation and closeness to the market give an advantage. Competition for sawlogs is currently keen and will become more intense. This will result in further rationalisation in the sawmilling industry, similar to that which has already occurred in the small diameter roundwood based industries. It is expected that further large mills processing around 100,000 m³ ob per annum of sawlogs will be built, and that many of the current smaller, medium sized mills will be either absorbed or forced out of business. Some mills will look to added value products to remain viable. Several small family owned and operated mills, often linked with a small fencing contracting business, are expected to continue as they require only small volumes of logs, supply markets within a limited distance and the cost of the sawntimber is only one component in their true business as contractors. For a long time the importers and suppliers have tended not to regard the British softwood industry as a serious competitor in the U.K. market. Considering the increasing production and upgrading of British sawntimber the trade which previously relied upon imports now has an opportunity to prosper by fostering the growing industry on its own doorstep. Since 80% of the sawntimber and timber products consumed in the U.K. goes into the construction industry the main aim will inevitably be to limit or eliminate unjustified technical barriers and restrictions on the use of timber. Research and technical training, with the help of TRADA, can reduce some of the inherited artificial barriers which militate against an increased use of a renewable resource.

The future of the world’s forests is not yet very high on the political agenda and forestry rarely achieves the same degree of status at government level as achieved by other more powerful interests. Forestry has an image problem and unless it can achieve a far broader base of support, Government planting targets will be difficult to achieve even in the U.K. Foresters generally have not been too successful in putting across their case to the public and much greater constructive use must be made of television and radio to show the importance of the forests which we create. With the growing concern about environmental issues in recent years foresters have frequently found themselves the target of the environmentalists’ wrath. However forestry in Britain has succeeded in retaining Government backing, in spite of a barrage of adverse publicity emanating from the battle between foresters and ‘conservationists’ in the very north of Scotland which indeed has little relevance to the U.K. forest industry as a whole. However in 1987 this pressure brought together a grouping of enterprises, organisations and professional associations within the private sector to form the Forest Industry Committee of Great Britain (FICGB), to promote an improved and more informed understanding of the contribution and role of the Forest Industry in Great Britain and overseas. Its first publication “Beyond 2000” is a well researched and a highly authoritative reference book which I would regard as essential reading for anyone associated with the forest industry in Great Britain. A strong united forest industry is a guarantee of continued support for the right reasons. It is a beacon of hope for the lonely forester harassed by sham conservationists. We may not find it easy for every link in the forestry chain to live together but our overall commitment is clear and the fact that we have held our place is a great tribute to both the FICGB and the Forestry Commission.

I am a forester, I am trained to look long term, it has not let me down whether it is a strategy for EFG or the forest industry. I leave you with a quotation from our Prime Minister Mrs. Margaret Thatcher from a speech made at the last Conservative Party Conference.

“We are in the business of planting trees for our children and our grandchildren or we
have no business to be in politics at all. We are not a one generation party, we do not intend to let Britain become a one generation society, let us not forget the lessons of history, the long term always starts today.”

REFERENCES


Commonwealth Forestry Review Paper: BRITISH FORESTRY

In his Budget speech on 15th March 1988, the Chancellor announced that with immediate effect commercial forestry would by removed completely from Income Tax and Corporation Tax. Expenditure on tree planting and forest management would therefore no longer be allowable as a deduction against other income for tax purposes, neither would grants and timber income be liable to tax. Transitional arrangements would be available for a period of 5 years for forest owners to choose between the previous tax relief arrangements and a new woodland grant scheme with greatly increased levels of planting grant which it is claimed provide the equivalent level of financial support.

In presenting his paper at the International Forestry Conference at Albury, New South Wales, Australia, on the 27th April 1988, John Campbell referred to the change from indirect to direct incentives, although this was too late to be included in the published Conference papers. This political decision represents a major turning point in the history of UK forestry. The Editor has decided that the published paper describes the ‘success story’ prior to the 1988 Budget and the author has agreed to contribute a short analysis of the effects of this change for a future issue.

John Campbell, O.B.E.
APPENDIX 3

**Softwood Lumber 1987**

UK Softwood Arrivals 1986/87

Volumes for 1987 of Softwood arrivals into the U.K. are up by approximately 9% on 1986 volumes.

<table>
<thead>
<tr>
<th>Country</th>
<th>1986 Volumes</th>
<th>1987 Volumes</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>1949</td>
<td>1800</td>
<td>27.8</td>
</tr>
<tr>
<td>Finland</td>
<td>968</td>
<td>1050</td>
<td>13.8</td>
</tr>
<tr>
<td>USSR</td>
<td>1062</td>
<td>1250</td>
<td>15.2</td>
</tr>
<tr>
<td>Canada East</td>
<td>308</td>
<td>450</td>
<td>4.4</td>
</tr>
<tr>
<td>Canada West</td>
<td>1229</td>
<td>1550</td>
<td>17.6</td>
</tr>
<tr>
<td>Portugal</td>
<td>635</td>
<td>640</td>
<td>9.1</td>
</tr>
<tr>
<td>Poland</td>
<td>189</td>
<td>200</td>
<td>2.7</td>
</tr>
<tr>
<td>Czech</td>
<td>223</td>
<td>240</td>
<td>3.2</td>
</tr>
<tr>
<td>Norway</td>
<td>88</td>
<td>90</td>
<td>1.2</td>
</tr>
<tr>
<td>Irish</td>
<td>80</td>
<td>90</td>
<td>1.2</td>
</tr>
<tr>
<td>USA</td>
<td>109</td>
<td>80</td>
<td>1.5</td>
</tr>
<tr>
<td>Brazil</td>
<td>47</td>
<td>40</td>
<td>0.7</td>
</tr>
<tr>
<td>Others</td>
<td>117</td>
<td>145</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7,004</strong></td>
<td><strong>7,625</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**000 m³ U.K. Softwood Arrivals 1981–1987**

<table>
<thead>
<tr>
<th>Year</th>
<th>Volumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>5165</td>
</tr>
<tr>
<td>1982</td>
<td>6085</td>
</tr>
<tr>
<td>1983</td>
<td>7155</td>
</tr>
<tr>
<td>1984</td>
<td>6686</td>
</tr>
<tr>
<td>1985</td>
<td>6111</td>
</tr>
<tr>
<td>1986</td>
<td>7004</td>
</tr>
<tr>
<td>1987</td>
<td>7625</td>
</tr>
</tbody>
</table>
EXISTING MAJOR INDUSTRIES IN GREAT BRITAIN

A. Small Diameter Roundwood Industries
   A1. Highland Forest Products - OSU
   A2. Cumbernauld Ltd - PHK
   A3. Cumbernauld Ltd. - PH
   A4. Thanev Wood Mills - R & P
   A5. Cairnshane Paper Mill - P & P
   A6. Fraser U.K. Ltd. - PH
   A7. Shielan Papr Mill - P & P
   A8. Kromann Ltd - PH
   A10. Munishaw Templey Mill - Fluting

B. Sawmilling Industries
   B1. Thomas Smith & Sons - Kilmaillie
   B2. Thomas Smith & Sons - Kirkcudbright
   B3. Thomas Smith & Sons - Bermside
   B4. A H Brownlie Ltd - Bered of Carter
   B5. A H Brownlie Ltd - Newbridge on Wy
   B6. A H Brownlie Ltd - Senghenyad
   B7. A H Brownlie Ltd - T. Beattian Howd
   B8. Jones Jones & Son - Alness
   B9. Jones Jones & Son - Forres
   B10. Jones Jones & Son - Quarriers
   B11. John Corson & Sons - Hain
   B12. John Corson & Sons - Carrbridge
   B13. Anne Wilson & Sons (Ayr) Ltd
   B14. J. Cornier & Sons Ltd
   B15. Robert Hedges & Sons Ltd
   B16. Thomas Roach Mills
   B17. Tulloch Sawmill
   B18. A. Corson & Sons Ltd.
   B20. Lawler & Crossdale Ltd
   B21. Anderson Bros. - Berrie Sawmill
   B22. John S. Hickey & Co. - Pantilina Rady
   B23. J. G. D Muir & Partners
   B24. Blüthner Ltd.
BIOMASS, PRODUCTIVITY AND WOOD WASTE EVALUATION IN A SPRUCE (PICEA ABIES) FOREST (STRAINCHAMPS 1983)

By ANNE TELLER*

SUMMARY

Biomass production was studied in an area of 40-year-old spruce forest in the Belgian Ardennes. The mean-tree method was used on a sample plot stratified by circumference class to evaluate the distribution of the biomass within the different organs of the tree. Total dry weight of aerial biomass was found to be 195 tonnes per hectare. The dry weight of leaves and branches was 19.5 tonnes per hectare for each of them. Needles are retained on the trees for at least 11 years. The most important part of the leaf biomass is concentrated in the upper part of the crown.

The part of the tree currently used for commercial purposes was calculated at 79% of the total biomass by the method of the mean tree and at 83% by the allometric method.

The total productivity of the forest is 19 tonnes per hectare per year. This study has demonstrated the use of techniques for the estimation of productivity in an even-aged spruce forest.

* Commission of the European Communities B–1049 Brussels
La productividad total del bosque fue de 19 toneladas por hectárea por año. Este estudio ha demostrado el uso de técnicas para la estimación de la productividad en un bosque coetáneo de abeto.

Introduction

To estimate the timber production, European foresters have used until now yield tables which, despite their accuracy, do not give any information about components of the tree other than commercial wood (i.e. branches, leaves, small trees, . . .) and express all the results in terms of volume. Because of the present need for new forms of energy and chemicals, other uses of trees have been investigated so that a renewal of interest in biomass studies has appeared (Pardé 1977, Bulletin des Communautés Européennes 1979, Piermont 1982). Rather than volume, dry matter estimates of all the parts of the tree are required to convert wood production into energy units as wood density varies according to species. Biomass and productivity studies are also important for a better understanding of the forest ecosystem itself. They indicate the production efficiency in relation to species. These data are also necessary to evaluate the effects of a whole tree harvest on the mineral equilibrium of the ecosystem.

In this study, I have concentrated on the evaluation of the crown (i.e. needles and branches) because little information exists on this at present.

Description of the Site

The forest is located in the province of Luxembourg in the south of Belgium. It is a production forest which belongs to the estate of Mrs Bary-Lenger.

The forest of 40-year old spruce is 7 ha in area. It has been managed commercially and is of average productivity in Luxembourg. All the trees have been pruned to 2 m height. Three thinnings have been carried out at ages 27, 33 and 40 years. The bedrock belongs to the syncline of Neufchateau and is made up of shist and quartz (Bary-Lenger & Kimus 1983). The soil is an acid brown forest soil or cambisol. The annual precipitation is about 980 mm, the average yearly temperature is 7°C. The climate is continental, with cold winters. Frost is common from October to May. Snowfall may occur from November until April (Delvaux & Galoux 1962).

The spruce forest is dense so that the field layer is composed of scattered individuals of Sambucus racemosa, Chamaenerion angustifolium, Dryopteris carthusiana, Dryopteris dilatata, Dryopteris Filix-mas, Fragaria vesca and Rubus spp.

The mean stand height was 20 m and top height 22 m.

The distribution of girth classes was normal (Fig. 1) with a mean circumference of 64.5 cm (i.e. 20.5 cm mean diameter). The mean basal area of the stand is 40.7 m$^2$ per ha (Table 1).
BIOMASS IN SPRUCE

Table 1
Mean values of characteristic measurements taken in the sample plot of the spruce at Strainchamps (1982).

<table>
<thead>
<tr>
<th>Variables</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stocking density</td>
<td>1162</td>
</tr>
<tr>
<td>Age</td>
<td>40</td>
</tr>
<tr>
<td>Mean height</td>
<td>20</td>
</tr>
<tr>
<td>Dominant height</td>
<td>22</td>
</tr>
<tr>
<td>Circumference at breast height</td>
<td>64.5</td>
</tr>
<tr>
<td>Mean tree basal area</td>
<td>350</td>
</tr>
</tbody>
</table>

Methodology
A sample plot of 0.48 ha was investigated. The circumference at breast height (1.3 m) of all trees within the plot was measured. Total height was measured for a subsample of 2 to 4 trees in each girth class (Dagnelie, Rondeux and Thill 1976) with a Blume-Leiss with an accuracy of ± 0.5 m (Nihlgard 1972).

To estimate the biomass and production, several procedures can be used. The method of the mean tree and the allometric method were chosen because of their common use in the literature.

— The method of the mean tree consists of measuring and weighing all the components of a tree in order to evaluate the distribution of the biomass within the tree and to estimate the annual production. The results are extrapolated to the whole stand. The sample tree belongs to the mean class for the chosen parameter (i.e. the girth in this study).

— The allometric method involves subsamples of trees belonging to the different girth classes being felled and weighed in the field. Subsamples are oven-dried and weighed in the laboratory. The regressions obtained from the sample trees are then applied to the stand to estimate the total tree biomass (Kestemont, Duvigneaud & Paulet 1977).

The Mean-tree Method
One tree belonging to the mean-girth class, i.e. 60 cm to 70 cm, was selected and felled. For practical reasons, the stump was cut at 15 cm above the soil surface. The below-ground biomass has not been considered.

The tree was weighed and measured entirely in the field. The crown was measured whorl by whorl. In each whorl, the branches were classified by age and diameter (Fig. 2).

Two discs of 5 and 10 cm in length were taken every 2 m from the part of the stem which was more than 7 cm diameter i.e. the commercial wood. The samples were brought back to the laboratory to determine the percentage of bark and to evaluate the growth increment by measuring the annual rings.

Figure 2. Cutting of the crown whorl by whorl.
The whole crown was brought to the laboratory and dried at 105°C. Needles were separated from the twigs and weighed. All the dead branches which were still on the tree were weighed separately too. They constitute the necromass (Kestemont 1975). Sample discs were cut at the base of the branches.

The age of the discs was obtained from the annual ring analysis. The increment, in millimetres, for the previous five years was measured of four radii. The production of stemwood was based on annual ring analysis of the discs and calculated for each log. The annual dry weight increment was calculated using the following formula:

\[
\% W = \frac{R^2 - r^2}{R^2} \times \frac{100}{5}
\]

where:
- \( R \) = radius of the disc
- \( a \) = radial growth in the last 5 years
- \( r = R - a \)
- \( W \) = weight increment

The average annual increment for the wood was estimated by using a weighted mean:

\[
\% W = \frac{\sum W_i \times D_i^2 + \sum W_{i+1} \times D_{i+1}^2}{D_i^2 + D_{i+1}^2}
\]

where:
- \( D_i \) = diameter of the stem at height \( i \)
- \( W_i \) = weight of whorl \( i \)

The annual increment of the stem bark was assumed to equal the annual increment of the stem wood. These percentages were multiplied by the dry weight of the stem bark and wood to obtain the productivity.

As we had separated the crown into separate whorls, it was easy to calculate the annual increment by dividing the dry weight of each branch by its age. The same calculation was applied for the needles since needles easily fell off during drying.

The total increment was then obtained from the formula:

\[
\% W = \frac{W_i}{\text{age}} \times \frac{100}{W_i}
\]

Results

An original feature of this study is that branches and needles were separated according to their age.

The annual growth of the branches was easy to distinguish in the young whorls only. After the eleventh whorl, the growth of the most recent year, corresponding to 1982, could be distinguished from the other preceding whorls only.

Fig. 3 shows the distribution of the weight of branches and needles according to the whorl they belong to in the tree. The necromass is also shown.

The total weight first increases from the top to the centre of the crown and then decreases towards the lower branches of the tree. In the upper part of the crown (whorls 1 to 11) the weight of the needles dominates and this is where the highest photosynthetic activity occurs. From whorls 11 to 19, the weight of needles decreases quickly and branchwood dominates. Finally, the total weight of both needles and branches suddenly decreases for whorls 5, 6 and 7. The reason is that whorl 7 is the one that grew during the
Figure 3. Biomass and necromass of the crown of the mean tree.
very dry summer of 1976. The growth of the 1977 whorl, which came out from the buds formed in 1976 was still affected. It is only in 1979 that the normal growth rate is recovered. The sensitivity of spruce to water stress is well known and its effect on growth is clearly demonstrated here.

Table 2
Biomass of the mean spruce (Strainchamps, 1982).

<table>
<thead>
<tr>
<th></th>
<th>Biomass (kg)</th>
<th>Biomass (T/ha)</th>
<th>% Above-ground Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WOODY ORGANS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Stem</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wood</td>
<td>123.036</td>
<td>143.0</td>
<td>73</td>
</tr>
<tr>
<td>bark</td>
<td>10.178</td>
<td>11.8</td>
<td>6</td>
</tr>
<tr>
<td>total</td>
<td>133.214</td>
<td>154.8</td>
<td>79</td>
</tr>
<tr>
<td>wood</td>
<td>1.431</td>
<td>1.7</td>
<td>1</td>
</tr>
<tr>
<td>bark</td>
<td>0.255</td>
<td>0.3</td>
<td>0</td>
</tr>
<tr>
<td>total</td>
<td>1.686</td>
<td>2.0</td>
<td>1</td>
</tr>
<tr>
<td>Total stem</td>
<td>134.900</td>
<td>156.8</td>
<td>80</td>
</tr>
<tr>
<td><strong>Branches</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 &lt; 1 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wood</td>
<td>4.021</td>
<td>4.7</td>
<td>2</td>
</tr>
<tr>
<td>bark</td>
<td>4.185</td>
<td>4.9</td>
<td>3</td>
</tr>
<tr>
<td>total</td>
<td>8.206</td>
<td>9.6</td>
<td>5</td>
</tr>
<tr>
<td>wood</td>
<td>6.259</td>
<td>7.3</td>
<td>2</td>
</tr>
<tr>
<td>bark</td>
<td>1.976</td>
<td>2.3</td>
<td>3</td>
</tr>
<tr>
<td>total</td>
<td>8.235</td>
<td>9.6</td>
<td>5</td>
</tr>
<tr>
<td>Total branches</td>
<td>16.441</td>
<td>19.2</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total wood</strong></td>
<td>151.341</td>
<td>176.0</td>
<td>90</td>
</tr>
<tr>
<td><strong>LEAVES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Needles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>3.283</td>
<td>3.8</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 1 year</td>
<td>13.385</td>
<td>15.6</td>
<td>8</td>
</tr>
<tr>
<td>total</td>
<td>16.668</td>
<td>19.4</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total crown</strong></td>
<td>33.108</td>
<td>38.6</td>
<td>20</td>
</tr>
<tr>
<td><strong>TOTAL BIOMASS</strong></td>
<td>168.009</td>
<td>195.4</td>
<td>100</td>
</tr>
<tr>
<td><strong>NECROMASS</strong></td>
<td>23.585</td>
<td>27.4</td>
<td>—</td>
</tr>
</tbody>
</table>

Table 2 gives the main results of the analysis of the sample tree which are summarized in Fig. 4. The aerial biomass totalled 195 T/ha. The biomass of needles at 19.4 T/ha, represents about 10% of the total biomass or as much as the branches. The commercial wood is consequently 155 T/ha or 79% of the total biomass.

Fig. 5 gives the main results of the growth analysis. Growth has been estimated at 8.2 T/ha/yr for the needles and 4.1 T/ha/yr for the branches and twigs. The total growth of the whole crown is thus 12.3 T/ha/yr. The growth of needles represent 43% of the total productivity and is very high. All the needles on the tree were weighed and classified by
The annual increment of weight of needles was not determined. The calculated productivity is taken as the mean between total age and total weight. Finally, the growth of the commercial wood is 6.5 T/ha/yr or 36% of the total growth.

The Allometric Method

For the estimation of the total biomass, eight trees belonging to girth classes 30 to 90 cm were (i.e. 10 at 30 cm diameter classes) selected and cut in the sample plot. The stems were weighed in the field. Sample discs of 5 and 10 cm long were cut both at the base of the trunk and at the top limit for commercial wood. The discs were taken to the laboratory for annual ring analysis and for the determination of the dry weight of both bark and wood. The branches from each tree were classified according to their whorls and within each whorl by their basal diameter (i.e. more or less than 1 cm). The dead branches were removed. Samples were taken from different parts of the crown within each diameter category. In the laboratory, dry weight was recorded without separating the needles from the twigs.
Results

To estimate the biomass of the trees one can adopt allometric regressions of the type \( Y = AX + B \), where \( Y \) is a dependent variable (e.g. the weight of the stem), \( X \) is an independent parameter (e.g. the girth at breast height), \( A \) is the regression coefficient and \( B \) the regression constant. Logarithmic regressions of the type \( Y = kX^A \) or \( \log Y = A \log X + B \) are the most commonly used for biomass studies. In the present study, I have applied the following parameters to the regressions of the sample trees:

1. \( Y = AX + B \)
2. \( Y = AX^2 + B \)
3. \( \log Y = A \log X + B \)
4. \( \log Y = A \log X^{\frac{3}{4}} + B \)
5. \( \log Y = A \log X^{\frac{3}{2}} + B \)

\( X \) = circumference at breast height.

<table>
<thead>
<tr>
<th>( Y = )</th>
<th>stem biomass</th>
<th>crown biomass</th>
<th>total biomass</th>
<th>no. of trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C )</td>
<td>0.988</td>
<td>0.966</td>
<td>0.991</td>
<td>9</td>
</tr>
<tr>
<td>( C^2 )</td>
<td>0.996</td>
<td>0.958</td>
<td>0.996</td>
<td>9</td>
</tr>
<tr>
<td>( \log C )</td>
<td>0.994</td>
<td>0.942</td>
<td>0.995</td>
<td>9</td>
</tr>
<tr>
<td>( \log C^{\frac{3}{4}} )</td>
<td>0.996</td>
<td>0.979</td>
<td>0.996</td>
<td>9</td>
</tr>
<tr>
<td>( \log C^{\frac{3}{2}} )</td>
<td>0.996</td>
<td>0.976</td>
<td>0.997</td>
<td>9</td>
</tr>
</tbody>
</table>

High correlation coefficients were found for almost every regression. The values of the first equation were applied to the stand calculations and the regression lines are given in Fig. 6.

Fig. 6 gives the main results of the analysis of the sample trees. Total biomass is 207 T/ha i.e. a little higher than with the previous method. Here, almost 83% of the biomass is concentrated in the commercial part of the stem. If we compare the histogram of girth classes with the one of biomass classes (Fig. 7), a shift between the two can be observed. This is because biomass, like volume, is proportional to the square of the diameter so that the use of mean circumference or diameter to determine the mean tree does not suit biomass studies very well.

Conclusion

The use of spruce for wood production does seem justified by its efficiency in concentrating on stem production. The proportion of so-called waste (i.e. branches, needles, end of the stem, bark) amounts to only 17 to 20%. In comparison, in Finland, Hakkila (1975) has estimated that about 33% of the volume of the total aerial biomass of spruce is wood-waste. Unfortunately there are no equivalent figures for the proportion of wood-waste in Belgium.

The first part of the study concentrated on assessing in detail the biomass and production of branches and needles along the tree. There is no widely accepted single method for doing this. The method of sampling as well as the number of samples to take, varies a great deal according to the author (Kestemont, Duvigneaud & Paulet 1977, Nihlgard 1972, Overend 1978, Riedacker 1969, ... ).
Figure 6. Allometric relation between total dry weight and circumference at breast height of the tree.

Figure 7. Total dry weight of each circumference class of the stand.
In this study, I have found that both biomass and productivity of the needles are as important as the biomass of the branches. The distribution of the weight of needles along the crown has been carefully studied too. The main photosynthetic activity is concentrated in the upper part of the tree. In the lower part however, needles are maintained for at least 11 years but their contribution to the photosynthetic activity is very low. Up to a certain age, the weight of the individual needle increases. After this age, their growth stabilizes. According to Heller (in Kestemont et al. 1977), the mean weight of a needle of spruce increases from 100 to 180 percent in 6 years. This maintenance represents a loss for the tree. High pruning, if economic, could improve the growth efficiency (Bary-Lenger 1983).

In the second part, more attention was paid to the evaluation of the biomass of the whole forest using allometric methods. These are more precise for the estimation of the total biomass of the stand since they take into account the quadratic relationship between circumference and biomass but do not provide any detail about the partition of weight within the tree. All the relations used for the correlation gave very good regressions. Allometric relations gave a better reflection of the total biomass of the stand since the incidence of the big trees on the total biomass is underestimated with the mean-tree method.

Biomass studies are very important to aid understanding of the forest ecosystem and to expand the traditional view that a forest should only be considered as a wood producer.

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THE USE OF BIOMASS ESTIMATIONS IN THE MANAGEMENT OF FORESTS FOR FUELWOOD AND FODDER PRODUCTION

By G. B. APPLEGATE¹, D. A. GILMOUR¹, and B. MOHNS²

SUMMARY

In many parts of the developing world forests are being established to provide fuelwood and fodder for rural peoples. Conventional mensurational techniques are inappropriate for assessing growth rates and for quantifying the multiplicity of forest products (foliage, branches and small stems as well as larger sized material) harvested from such forests. Biomass estimation techniques involving regression analysis are well suited to provide the information required for assessing the weight of various stand components.

The biomass data from a plantation of nine year old chir pine (*Pinus roxburghii* Sargent) in the Middle Hills of Nepal are extrapolated and used to develop a simple utilisation schedule suitable for application at local level.

RÉSUMÉ

Dans beaucoup d’endroits des pays en voie de développement on établie des forêts pour fournir du bois de chauffage et du fourrage pour les populations rurales. Les techniques classiques de dendrométrie sont peu appropriées pour évaluer les taux d’accroissement et pour déterminer la quantité de la multiplicité de produits forestiers (le feuillage, les branches et les tiges de petite taille bien que du matériel plus grand) récoltée de telles forêts. Les techniques d’estimation de biomasse qui comprennent l’analyse de régression conviennent bien à fournir les données nécessaires pour l’évaluation du poids de divers composants des peuplements.

Les données de biomasse d’un peuplement de *Pinus roxburghii* Sargent âgé de neuf ans dans les Middle Hills du Népal sont extrapolées et utilisées pour développer un programme simple d’utilisation qui convient d’être appliqué au niveau local.

RESUMEN

En muchas partes de los países en desarrollo se están estableciendo bosques para abastecer de leña y forraje a la población rural. Las técnicas convencionales de medición son inapropiadas para la evaluación e tasas de crecimiento y para la cuantificación de la multiplicidad de productos forestales (follaje, ramas y fustes pequeños, así como material de mayores dimensiones) cosechado de tales bosques.

Se consideran adecuadas las técnicas de estimación de biomasa que utilizan análisis de regresión, para proveer la información requerida para evaluar el peso de los diferentes componentes del rodal.

Se extrapoló y usó la información de biomasa de una plantación de nueve años de *Pinus roxburghii* Sargent, de la cordillera central de Nepal, para desarrollar un esquema de utilización simple adecuado para la aplicación a nivel local.

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² Department of Forestry, Australian National University, Canberra, Australia.
Introduction

Forests in developing countries provide the local population with many of the products they require for their daily subsistence and are the main sources of fuelwood, timber and a range of minor products. In many countries, such as Nepal, the forests are also a significant source of fodder for livestock production. Utilization rates for the various products have been reported extensively by others.

In conventional forestry, consideration is generally given principally, if not solely, to the utilization of tree stems for industrial use. Consequently mensuration has been primarily directed towards developing techniques aimed at expressing forest growth and productivity in terms of merchantable log volume (Young 1971). By contrast, in many of the recently established community forests in developing countries all the forest components will be used — branches, foliage and stems. In some cases even the roots will be dug out and used as fuelwood.

The management of community forests requires the development of mensurational techniques to provide data which are applicable to such multifaceted utilization patterns. Biomass measurements are well suited to provide the information required but need to be presented in such a way that they can be understood and interpreted by village people. Only simple management systems will be suitable for implementation by local communities with very limited input from technically trained staff. If this breakthrough can be made, it opens the way for widespread and effective community involvement in the sound scientific management of community forests.

This paper discusses the use of regression analysis for the determination of biomass estimations in community forests. An example is given of the use of biomass estimations, derived from regression analysis, in the scheduling of utilization from communal plantations established by the Nepal-Australia Forestry Project in Sindhu Palchok District in the Middle Hills of Nepal. Further information on the Projects can be found in Shepherd (1981), Gilmour and Applegate (1984) and Shepherd and Griffin (1984).

Biomass Techniques

Biomass is the amount of living organic matter accumulation on a unit area at a specified point in time (Newbould 1967). It should not be confused with productivity, which is a measure of biomass accumulation over time (Satoo 1970). Biomass estimates for forests are generally expressed on an oven dry weight basis per unit of land area.

Forest ecosystems usually comprise numerous species in several strata above ground, as well as litter at the soil surface and roots within the soil. Although about 20% of the forest biomass is contained in the roots (Rodin and Bazilevich 1967), for most practical purposes the amount of root material is of little interest although techniques are available for measuring this component (Moir and Bachelard 1969; Huttel 1975; Applegate 1982).

As it is generally impractical to weigh all components of a stand, some form of sampling is necessary. The techniques employed to estimate stand biomass depend on the nature, size and distribution of the stand fractions (Ribe 1979) and often combinations of methods are used (Kozak 1970). The main methods used in biomass studies have been described by Parde (1980) and Satoo and Madgwick (1982). Regression analysis is one of the common methods because of its simplicity in determining estimates and the ease with which results can be applied. This method relates easily measurable variables such as the diameter and height to the component biomass of the forest fractions (Baskerville 1972; Madgwick and Satoo 1975).
Regression analysis has the advantage that once equations are developed and validated they can be used for similar forest types on a wide range of sites in a particular geographic region (Satoo and Madgwick 1982). Whittaker and Marks (1975) and Applegate (1982) found that similar regression models can be used to estimate the biomass of plants which are very different in morphology and habit. This situation prevails in many forests where the variability of the forests is due to the difference in size and shape of the trees, the complex pattern of species distribution and the haphazard use of the forest fractions by the local villagers. The determination of forest biomass estimates is simplified if one equation can be applied to different species within each forest type. Regression analysis techniques under these forest conditions are better suited than other techniques such as the mean tree method which is more applicable to plantations of trees which are relatively uniform in size (Whittaker and Woodwell 1960; Art and Marks 1971).

Biomass tables derived from the regression equation, along with relatively simple inventory data such as stocking and mean tree size can then be combined to determine biomass estimates of the various forest components. In situations where different regression equations are required for different species, inventory data will also need to be recorded by appropriate species. The regression analysis approach can provide the manager, who may have only rudimentary technical training, with the mensurational tools to predict the amount of produce which would come from a forest under any prescribed utilization strategy.

Case Study from Nepal

Most of the land available for plantation establishment in Sindhu Palchok District, and indeed elsewhere in Nepal, was formerly covered by forest but through misuse or over use the forest cover has become severely depleted. In many cases the forest has been reduced to a shrubbery or has completely disappeared and the soils are frequently moderately to severely eroded. It is often impossible to establish broadleaf species on such deforested land because of the exposed nature of the site and the degraded soils, even though broadleaf species are highly favoured by the local people for both fuelwood and fodder. Chir pine (*Pinus roxburghii* Sargent) is a less highly favoured but hardier pioneer species, able to establish itself readily on difficult sites and so has been a major component of these recently established plantations. A case study is presented to illustrate the use of biomass estimations, derived from regression analysis, to schedule utilization operations in such a chir pine stand. The study was carried out in a high quality stand which was found to correspond to Site Quality I of the Indian Yield Tables for chir pine.

The study area is located about 40km north east of Kathmandu at an altitude of 1500m near the town of Chautara. The land prior to planting was degraded grassland and contained little or no broadleaf fraction. At age nine years the chir pine plantation had a predominant height of 8.7m, a mean diameter breast height at 1.3m (dbh) of 11.4cm and a stocking of 1400 stems per hectare.

Determination of the regression equations

Plots were established within an extensive area of the chir pine plantation. Stand characteristics including a diameter – frequency distribution were determined. Eighteen chir pine trees within a diameter range of 3.5 to 17.9 cm were selected for detailed measurements. The diameter of each tree selected was recorded at breast height and at
Table 1

Above ground biomass (expressed as oven dry weight) of various stand components of a chir pine plantation for age 6 to 14 years on a high quality site at Chautara.

<table>
<thead>
<tr>
<th>Approx. Age (years)</th>
<th>Mean dbh (cm)</th>
<th>Pre. Ht (m)</th>
<th>Probable Stocking (stems ha⁻¹)</th>
<th>Standing Biomass (t ha⁻¹)¹</th>
<th>Foliage and branchwood by stem section</th>
<th>Complete tree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0-10% Foliage Branch wood</td>
<td>10-20% Foliage Branch wood</td>
</tr>
<tr>
<td>6</td>
<td>6.6</td>
<td>4.0</td>
<td>1400</td>
<td>0.30</td>
<td>0.92</td>
<td>0.17</td>
</tr>
<tr>
<td>7</td>
<td>8.2</td>
<td>5.5</td>
<td>1400</td>
<td>0.42</td>
<td>1.59</td>
<td>0.32</td>
</tr>
<tr>
<td>8</td>
<td>9.8</td>
<td>7.0</td>
<td>1400</td>
<td>0.48</td>
<td>1.99</td>
<td>0.41</td>
</tr>
<tr>
<td>9</td>
<td>11.4</td>
<td>8.7</td>
<td>1300</td>
<td>0.57</td>
<td>2.72</td>
<td>0.58</td>
</tr>
<tr>
<td>10</td>
<td>12.8</td>
<td>9.5</td>
<td>1190</td>
<td>0.58</td>
<td>2.95</td>
<td>0.64</td>
</tr>
<tr>
<td>11</td>
<td>13.2</td>
<td>10.3</td>
<td>1100</td>
<td>0.59</td>
<td>3.19</td>
<td>0.70</td>
</tr>
<tr>
<td>12</td>
<td>14.6</td>
<td>11.1</td>
<td>1000</td>
<td>0.58</td>
<td>3.35</td>
<td>0.75</td>
</tr>
<tr>
<td>13</td>
<td>16.0</td>
<td>11.9</td>
<td>900</td>
<td>0.62</td>
<td>3.91</td>
<td>0.90</td>
</tr>
<tr>
<td>14</td>
<td>17.4</td>
<td>12.7</td>
<td>800</td>
<td>0.59</td>
<td>3.92</td>
<td>1.15</td>
</tr>
</tbody>
</table>

1 dbh for ages greater than 9 years conservatively estimated using a MAI of 1.4 cm yr⁻¹ (based on the estimated MAI from years 6 to 10 of 1.6 cm yr⁻¹).
2 Predominant height for ages greater than 9 years conservatively estimated using a MAI of 0.8 m yr⁻¹.
3 Stocking based on a planting rate of 1750 ha⁻¹, a survival of 80%, and a probable thinning schedule.
4 Component biomass determined from tables calculated from regression equations.
5 The biomass shown below the dotted line would normally be removed during pruning operations.
0.3 m prior to cutting at ground level. The main stem was divided into five equal lengths with the lowest section being further divided into halves. The branches from each stem section were removed, stripped of foliage and the weights of the stems, branchwood and foliage were recorded. To enable the biomass estimations to be expressed in terms of oven dry weight, samples were taken from all components and oven dried at 95°C until constant weight was attained. Dry matter percentage was then calculated for each component. Discs at 1.3 m above ground level were removed from all sample trees to determine tree diameters at various past ages.

Regression equations of the form: \( \ln Y = a + b \ln X \) (where \( Y = \) biomass in grams and \( X = \) dbh in millimetres) were calculated relating dbh of the sample trees to the weight of stem, branchwood and foliage for the complete tree, and the weight of the branchwood and foliage for each of the six stem sections.

**Determination of biomass productivity**

The productivity of multi-product forests will determine to a large degree the scheduling of the amount of produce which can be harvested. The measure of productivity, or an estimate of biomass changes in the forest over time, will then provide a data base on which sound management decisions can be made while ensuring that utilization and silvicultural objectives are met. The standard method for estimating stand growth is the repeated measurement over time of parameters such as mean dbh, predominant height and stocking (Husch, Miller and Beers, 1982). Such growth information is not immediately available for most community forests. However the stem analysis data enabled the mean annual increments (MAI) to be determined and used to predict future growth. These data were used in conjunction with biomass regression equations and predicted stocking rates to provide estimations of stand biomass at different stages of stand development (Mawson 1982). Table 1 shows the predicted above-ground biomass of a high quality chir pine stand ranging in age from 6 to 14 years.

**Management Applications**

Before any decision is made regarding management strategies to be applied to a forest, the silvicultural and utilization objectives of management must be determined and clearly stated. The actual details for utilization in any particular plantation will vary greatly depending on both technical and social considerations *i.e.* on the floristic and structural composition of the stand and on the needs of the user group at any particular time. A small range of options can be developed so that users can decide which strategies they prefer while still ensuring that the long term productivity of the forest is not impaired.

It is generally important to commence utilization as early as possible in order to provide for the needs of the local farmers who have protected the forest and foregone their traditional rights of usage. At this early stage in the development of management schemes for community forests, it is desirable to plan for a utilization pattern which yields a relatively constant amount of produce annually. During a year, however, the detailed patterns of demand and use of each product change from month to month (Stone, 1980; Wiart, 1983; Mahat, 1985). Management schemes are more likely to gain ready acceptance if traditional collection times are maintained and incorporated in them.
Table 2
Treatment schedule and estimated yield (expressed as oven dry weight) for a chir pine plantation for age 6 to 10 years on a high quality site at Chautara.

<table>
<thead>
<tr>
<th>Predominant Height (m)</th>
<th>Approx Age (years)</th>
<th>Mean dbh (cm)</th>
<th>Treatment Schedule</th>
<th>Biomass harvested (t ha⁻¹)</th>
<th>Total yield up to age 10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Foliage Branchwood Stem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>6.6</td>
<td>Prune to 10% of stem (to approx. 0.4 m)</td>
<td>0.30 0.92 -</td>
<td>1.22</td>
</tr>
<tr>
<td>5.5</td>
<td>7</td>
<td>8.2</td>
<td>Prune from 10% to 20% of stem (to approx. 1.1 m)</td>
<td>0.32 0.91 -</td>
<td>1.23</td>
</tr>
<tr>
<td>7.0</td>
<td>8</td>
<td>9.8</td>
<td>Prune from 20% to 40% of stem (to approx. 2.8 m)</td>
<td>1.69 2.64 -</td>
<td>4.33</td>
</tr>
<tr>
<td>8.7</td>
<td>9</td>
<td>11.4</td>
<td>Remove multistems and thin to 1300 stems ha⁻¹ (remove 1 in 15 trees)</td>
<td>0.30¹ 0.56¹ 1.16</td>
<td>2.10</td>
</tr>
<tr>
<td>9.5</td>
<td>10</td>
<td>12.8</td>
<td>Thin to 1190 stems ha⁻¹ (remove 1 in 12 trees)</td>
<td>0.52² 0.79² 1.53</td>
<td>2.84</td>
</tr>
</tbody>
</table>

¹ Calculated on a proportional basis assuming 68 per cent of the height of the thinned trees is unpruned.
² Calculated on a proportional basis assuming 70 per cent of the height of the thinned trees is unpruned.
³ Refilling of seedlings was carried out for up to 4 years following initial establishment because of poor survival. This resulted in a stocking at age of 1400 stems per hectare.

Table 2 shows one possible utilization schedule from year 6 to year 10 for a chir pine plantation. This schedule is relatively conservative and after utilisation is completed in year 10, the standing biomass will still amount to 26.33 T ha⁻¹ of which 85% is woody material (stem and branchwood). From year 10 on, greater emphasis would be given to thinning the stand, whereas prior to this, products come mainly from pruned material and multistemmed trees.

In many plantations in Nepal which are afforded protection from grazing and fire, natural regeneration of broadleaf tree species occurs after plantation establishment with pines. Because the broadleaf component is more highly favoured by local people than the pine component, in certain places management of the forest may consist of heavy thinning in the pine fraction to favour the growth of the broadleaf fraction. Inventory of the forest as a whole requires biomass information for all stand fractions and components. Studies are continuing at Chautara to further develop biomass estimations for the new forest and to test existing equations in the field for species already studied.

Conclusions
The techniques outlined are by no mean the only possible approach to determining the quantity of the various stand components available from forests. However, measurements of component biomass provide a useful tool for the development of utilization schedules which are both silviculturally appropriate and easily understandable by local people who will have to implement them. This is the beginning of sound, practical management of multi-product forests for local use.
Acknowledgements

The work described in this paper was completed while two authors (G.B.A. and D.A.G.) were staff members of the Nepal-Australia Forestry Project. The project is a bi-lateral aid project between His Majesty's Government of Nepal and the Australian Government and managed by the Department of Forestry, Australian National University, Canberra, Australia. The third (B.M.) was a Ph.D. student of the Australian National University working in association with the Project.

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COMPARATIVE GROWTH OF FIVE TROPICAL ACACIAS ON FOUR DIFFERENT SITES IN SABAH

By SIM BOON LIANG* and E. GAN**

SUMMARY
The trial comprising 15 provenances of five tropical Acacia species was replicated on four different sites in Sabah. The first year height growth indicates that, on poor site such as rocky, shallow and sandy soil with heavy lalang (Imperata cylindrica) infestation, all provenances of A. crassicarpa and A. aulacocarpa, and some provenances of A. auriculiformis are significantly taller than A. mangium, a popular plantation species in Sabah. On this poor site, A. crassicarpa is found to be taller than A. mangium by 73% while A. aulacocarpa and A. auriculiformis are 45% and 23% taller respectively at year 1. On fertile site with dense weed of Eupatorium odoratum, these species also outperform A. mangium, indicating their greater capabilities to compete with and dominate this fast growing weed. These three species, however, do not show any superiority over A. mangium growing on good site with clean ground. On the highland, A. mearnsii is the most vigorous species. Early result of the trial indicates the good potential of these three Acacia species in the humid tropics, especially in rehabilitation of grassy wasteland.

RESUME
L’essai comprenant 15 provenances de cinq essences tropicaux d’Acacia était répété sur quatre sites différents en Sabah. La croissance en hauteur de la première année montre que sur un site peu fertile, avec un sol rocheux, peu profond et sableux avec une forte invasion a d’imperata (Imperata cylindrica), toutes les provenances d’A. crassicarpa et A. aulacocarpa et quelques provenances d’A. auriculiformis sont significativement plus grandes qu’A. mangium, une essence populaire de plantation en Sabah. Sur ce site peu fertile A. crassicarpa est 73% plus grand qu’A. mangium, pendant qu’A. aulacocarpa et A. auriculiformis sont 45% et 23% plus grands respectivement à la fin de la première année. Ces essences dépAssent A. mangium aussi sur un site fertile avec un salissement dense d’Eupatorium odoratum, montrant leur capacité plus grande pour concurrencer et dominer cette mauvaise herbe à croissance rapide. Pourtant ces trois essences ne montrent aucune supériorité à A. mangium croissant sur un site fertile avec un sol désherbé. Sur les pays montagneux A. mearnsii est l’essence la plus vigoureuse. Les résultats préliminaires de l’essai montre le potentiel de ces trois essences d’Acacia dans les tropiques humides, surtout pour la réhabilitation des friches herbeuses.

RESUMEN
Un ensayo que incluy6 15 procedencias de cinco especies tropicales de Acacia se replicó en cuatro sitios diferentes en Sabah. El primer año de crecimiento en altura indica que en un sitio pobre, con un suelo rocoso, superficial y arenoso, y con una infestación alta de Imperata cylindrica, todas las procedencias de A. crassicarpa y A. aulacocarpa, y algunas procedencias de A. auriculiformis, fueron significativamente

más altas que *A. mangium*, una especie popular para plantaciones en Sabah. En ese mismo sitio, se encontró que el crecimiento en altura que presentaba *A. crassicarpa* a un año de edad, era 73% mayor que el que de *A. mangium*, mientras que el de *A. aulacocarpa* y *A. auriculiformis* eran 45% y 23% más altos respectivamente. En un sitio fértil, con una presencia densa de la maleza *Eupatorium odoratum*, estas mismas especies superaron *A. mangium*, lo que indica su mayor capacidad para competir y dominar a esta maleza de rápido crecimiento. Sin embargo, estas tres especies no mostraron ninguna superioridad sobre *A. mangium* en sitios buenos y libres de malezas. En tierras altas, *A. mearnsii* mostró ser la especie más vigorosa. Los resultados preliminares de este ensayo indican el buen potencial que presentan estas tres especies en los trópicos húmedos, especialmente en la rehabilitación de tierras abandonadas e invadidas por gramíneas.

**Introduction**

*Acacia mangium* and several related Acacias belong to a small group of acacias that are native to the lowland wet tropics. These species are adapted to hot, humid conditions and possess the characteristic acacia robustness and adaptability. They are leguminous trees with the innate abilities of a pioneering plant. These attributes make them of great importance in the rehabilitation of eroding, weed — smothered terrain or degraded grassland.

Tree species can often perform in unexpected ways when introduced to new locations. *A. mangium* exemplifies this. In 1966, this tree was introduced to Sabah, Malaysia, from its natural range along the margins of tropical moist forests in Queensland, Australia. It grew so well that it was tested in plantations. There, the species grew as fast, or faster than, *Gmelina arborea* and *Eucalyptus deglupta* both among the most rapidly growing trees in the humid tropics. On poor sites such as eroded, rocky, thin mineral, acidic soils and hillslopes infested with weeds such as *Imperata cylindrica* and *Eupatorium* species, *A. mangium* notably outperformed the other species (National Academy of Sciences, 1983). Today, *A. mangium* is an important plantation species in Sabah and foresters have converted many thousand hectares of degraded land into productive plantations. Forestry organisations such as Sabah Forestry Development Authority (SAFODA) are reforesting wasteland with *A. mangium* while the Sabah Forest Industries (SFI) also uses this species in its initial plantings.

Because of the ease of establishment, *A. mangium* has become a popular legume species in the wet tropics. It is often the only species planted in cases of rehabilitating degraded grassland and sandy sites. There is, therefore, a growing concern about the underlying dangers of monoculture arising from planting huge areas with this single species. Efforts have been channelled to identifying other potential species with the view of securing a few more species that can compliment or even substitute for *A. mangium*.

*Acacia mangium* originates from the humid tropical region of northern Australia, Papua New Guinea and eastern Indonesia. However, it is not the only *Acacia* species from this part of the world. In or near its native habitat are also found *A. aulacocarpa*, *A. crassicarpa*, *A. auriculiformis* and several other species. These species appear to be adaptable, colonising species which may grow with little help in some problem soils that are poor in nutrients. They have wood properties similar to those of *A. mangium* and could well be very fast growing. However, very few of these species have been tried in plantations although they may have considerable potential. It is with the objective of testing these *Acacia* species on a range of sites that this species trial was established.
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Seed Sources
The trial comprises 15 species and provenances including a provenance of *A. mearnsii* a species more suited to the cool and moist areas. Seed of most of the provenances was supplied by the CSIRO of Australia. The list of the seed sources is given below.

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>Species</th>
<th>Seed Source</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Altitude (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>A. mangium</em></td>
<td>PNG</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td><em>A. auriculiformis</em></td>
<td>Balamuk, PNG</td>
<td>8°54' S</td>
<td>141°18' E</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td><em>A. auriculiformis</em></td>
<td>Iokwa, PNG</td>
<td>8°41' S</td>
<td>141°29' E</td>
<td>35</td>
</tr>
<tr>
<td>4</td>
<td><em>A. auriculiformis</em></td>
<td>Bula, PNG</td>
<td>9°09' S</td>
<td>141°20’ E</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td><em>A. auriculiformis</em></td>
<td>Yigo, Guam</td>
<td>16°35' N</td>
<td>45°25’ W</td>
<td>450</td>
</tr>
<tr>
<td>6</td>
<td><em>A. auriculiformis</em></td>
<td>Sepilok, Sabah</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>7</td>
<td><em>A. crassicarpa</em></td>
<td>Wemenever, PNG</td>
<td>8°42’ S</td>
<td>141°24’ E</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td><em>A. crassicarpa</em></td>
<td>Mata, PNG</td>
<td>8°40’ S</td>
<td>141°45’ E</td>
<td>30</td>
</tr>
<tr>
<td>9</td>
<td><em>A. crassicarpa</em></td>
<td>Oriomo River, PNG</td>
<td>8°49’ S</td>
<td>143°09’ E</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td><em>A. crassicarpa</em></td>
<td>Woroi/Wipim, PNG</td>
<td>8°49’ S</td>
<td>143°00’ E</td>
<td>20</td>
</tr>
<tr>
<td>11</td>
<td><em>A. aulacocarpa</em></td>
<td>Keru, PNG</td>
<td>8°32’ S</td>
<td>141°45’ E</td>
<td>40</td>
</tr>
<tr>
<td>12</td>
<td><em>A. aulacocarpa</em></td>
<td>Oriomo River, PNG</td>
<td>8°48’ S</td>
<td>143°09’ E</td>
<td>20</td>
</tr>
<tr>
<td>13</td>
<td><em>A. aulacocarpa</em></td>
<td>Iokwa, PNG</td>
<td>8°41’ S</td>
<td>141°29’ E</td>
<td>35</td>
</tr>
<tr>
<td>14</td>
<td><em>A. mearnsii</em></td>
<td>South Africa</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>15</td>
<td><em>A. mangium</em></td>
<td>Tawau, Sabah</td>
<td>4°25’ N</td>
<td>118°00’ E</td>
<td>—</td>
</tr>
</tbody>
</table>

Site Locations and characteristics
The trial was replicated on four representative sites within the Sabah Forest Industries (SFI) boundary at Sipitang Sabah. These four sites represent a range of environmental conditions. A description of these sites is given in Table 2.

The series of 4 sites are distinctive from each other in the following characteristics:

- **Altitude** — The sites represent a gradual increase in altitude from 100 m.a.s.l. at site A to 1300 m.a.s.l. at site D.

- **Soil** — Apart from site B, the sites generally have deep, moderately fertile and well drained soil. Site B is a poor rocky site with shallow and sandy soil.

- **Ground Condition** — Site A and C are both average lowland sites with deep loamy clay. Site A is distinct from site C in that it represents a poor ground preparation before planting. The ground was densely covered with Siam Weed and grasses. Site C, however, had a relatively clean ground condition at time of planting. Site B had a heavy infestation of lalang and tropical bracken at the time of planting. At the highland site (D), the initial ground condition was clean.

Experimental design
The trial was laid out in a randomised complete block design (RCB) with four replicates. They were 16-tree square plots planted at 3 x 3 m spacing.
Table 2
Site Characteristics

<table>
<thead>
<tr>
<th>Location</th>
<th>Altitude (m)</th>
<th>Mean annual rainfall (mm)</th>
<th>Mean annual temperature (°C)</th>
<th>Local relief</th>
<th>Aspect</th>
<th>Parent material</th>
<th>Soil family</th>
<th>Soil texture</th>
<th>Soil depth (cm)</th>
<th>Drainage</th>
<th>Soil pH</th>
<th>Natural vegetation</th>
<th>Ground Conditions prior to planting</th>
</tr>
</thead>
<tbody>
<tr>
<td>A L42</td>
<td>100</td>
<td>3100</td>
<td>28, 21</td>
<td>Slope</td>
<td>NW</td>
<td>Mudstone/ Siltstone</td>
<td>Kumansi</td>
<td>Loam</td>
<td>&gt; 100</td>
<td>Free draining</td>
<td>4.5–6.0</td>
<td>Forest; <em>Eupatorium odoratum</em>, Wild bananas and grasses after clear-felling</td>
<td>Weedy</td>
</tr>
<tr>
<td>B L39</td>
<td>500</td>
<td>3100</td>
<td>28, 21</td>
<td>Flat</td>
<td>E</td>
<td>Sandstone</td>
<td>Tanjung Lipat</td>
<td>Sandy Loam</td>
<td>~ 50</td>
<td>Free draining</td>
<td>4.5–6.0</td>
<td>Burnt forest; Lalong and fern after clearfelling</td>
<td>Weedy</td>
</tr>
<tr>
<td>C L21</td>
<td>650</td>
<td>3200</td>
<td>32, 21</td>
<td>Ridge top slope</td>
<td>SE</td>
<td>Mudstone/ Siltstone</td>
<td>Kumansi</td>
<td>Clay Loam</td>
<td>&gt; 100</td>
<td>Free draining</td>
<td>4.5–6.0</td>
<td>Forest; <em>Eupatorium odoratum</em> and shrubs after clearing</td>
<td>Clean</td>
</tr>
<tr>
<td>D P3</td>
<td>1300</td>
<td>2000</td>
<td>25, 15</td>
<td>Slope</td>
<td>SW</td>
<td>Sandstone</td>
<td>Tanjung Lipat</td>
<td>Clay Loam</td>
<td>50–100</td>
<td>Free draining</td>
<td>4.5–6.0</td>
<td></td>
<td>Clean</td>
</tr>
</tbody>
</table>

Establishment and management

Site preparation included clear-felling of existing vegetation and burning. In the case of delayed planting, slashing of the regeneration was carried out. Potted seedlings of an average height of 40 cm were used. They were planted in holes of approximately 20 cm deep and 10 cm in diameter. Routine maintenance included circle weeding and slashing which were carried out when necessary, usually at about 3 month intervals. No. other treatments, such as manuring, were applied.

Results

Only height growth has been assessed and measurements were carried out at 3 months, 6 months and 1 year after establishment. However, only the 1 year results are discussed here. The details are presented in Table 3 and Figs. 1–4.
Table 3
Mean Height of the provenances on 4 sites at the age of 1 year.

<table>
<thead>
<tr>
<th>Treatment #</th>
<th>Species</th>
<th>Mean height (m)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Site A</td>
<td>Site B</td>
<td>Site C</td>
<td>Site D</td>
</tr>
<tr>
<td>1</td>
<td>A. mangium</td>
<td>2.0</td>
<td>2.7</td>
<td>—</td>
<td>1.9</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>1.5</td>
<td>1.8</td>
<td>4.2</td>
<td>2.2</td>
</tr>
<tr>
<td>2</td>
<td>A. auriculiformis</td>
<td>2.1</td>
<td>2.9</td>
<td>3.6</td>
<td>1.7</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>2.4</td>
<td>3.1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4</td>
<td>A. auriculiformis</td>
<td>2.0</td>
<td>2.8</td>
<td>2.3</td>
<td>—</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>2.2</td>
<td>2.4</td>
<td>3.4</td>
<td>1.6</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>1.6</td>
<td>2.2</td>
<td>2.9</td>
<td>1.1</td>
</tr>
<tr>
<td>7</td>
<td>A. crassicarpa</td>
<td>2.8</td>
<td>3.8</td>
<td>4.4</td>
<td>3.3</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>2.2</td>
<td>3.8</td>
<td>4.5</td>
<td>2.5</td>
</tr>
<tr>
<td>9</td>
<td>A. crassicarpa</td>
<td>2.6</td>
<td>3.5</td>
<td>5.1</td>
<td>2.9</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>2.0</td>
<td>4.2</td>
<td>4.7</td>
<td>2.8</td>
</tr>
<tr>
<td>11</td>
<td>A. aulacocarpa</td>
<td>2.5</td>
<td>3.3</td>
<td>3.5</td>
<td>—</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>2.1</td>
<td>3.0</td>
<td>3.9</td>
<td>1.9</td>
</tr>
<tr>
<td>13</td>
<td>A. aulacocarpa</td>
<td>1.9</td>
<td>3.1</td>
<td>3.5</td>
<td>2.1</td>
</tr>
<tr>
<td>14</td>
<td>A. mearnsii</td>
<td>0.8</td>
<td>1.1</td>
<td>4.0</td>
<td>4.2</td>
</tr>
<tr>
<td>Population Mean</td>
<td></td>
<td>2.0</td>
<td>2.9</td>
<td>3.9</td>
<td>2.4</td>
</tr>
<tr>
<td>LSD (P &lt; 0.01)</td>
<td></td>
<td>±0.8</td>
<td>±0.9</td>
<td>±1.3</td>
<td>±1.0</td>
</tr>
</tbody>
</table>

(a) Site A (100 m.a.s.l.; good soil; weedy field condition)
The analysis of variance indicates significant differences among the species and provenances. In general, the results indicate that the A. aulacocarpa, A. crassicarpa and A. auriculiformis appear to outperform the A. mangium. Among them, the Keru A. aulacocarpa, Wemenever and Oriomo River A. crassicarpa and Iokwa A. auriculiformis are found to be significantly (P 0.01) taller than the local commercial seedlot of A. mangium (treatment # 16).

Of these three Acacia species, A. aulacocarpa seems to be the most promising. It exhibits good stem form with cylindrical trunk, single leader and reasonably fine branching. The stem form of A. crassicarpa is acceptable but there is a tendency for the stem to bend at the nodes. The species also has good apical dominance. Most of the A. auriculiformis, on the other hand, have poorer form and weak apical dominance. The PNG provenances, however, produce some fairly straight trees with single leader. The Iokwa provenance appears to be the best.

Despite the dense ground cover of Siam Weed (Eupatorium odoratum), the Acacia species are able to compete successfully and dominate the site. The only exception is A. mearnsii which performs very badly on this lowland site. It is unable to compete with the weeds and survival is poor.
Figure 1. Mean ht of the provenances at the age of 1 year on site A.

Figure 2. Mean ht of the provenances at the age of 1 year on site B.

Figure 3. Mean ht of the provenances at the age of 1 year on site C.

Figure 4. Mean ht of the provenances at the age of 1 year on site D.
(b) Site B (500 m.a.s.l.; rocky, skeletal soil; lalang infested)
Again taking the local A. mangium provenance from Tawau (treatment 16) as a base for comparison, all provenances of A. crassicarpa and A. aulacocarpa, and three provenances of A. auriculiformis prove to be more vigorous by at least one LSD at P < 0.1. The three A. auriculiformis provenances are all from PNG i.e. the Balamuk, Iokwa and Bula provenances of which the most outstanding is the Iokwa, The Woroi/Wipim and Keru provenances (both of PNG) are the best A. crassicarpa and A. auriculiformis respectively. On this hostile site, these three species have statistically outperformed A. mangium. These species are therefore more tolerable to poor soil, compete with and dominate the lalang, and would have great potential to substitute for A. mangium in the afforestation of poor sites.

As in the case of site A, A. aulacocarpa again shows the best stem form with strong apical dominance and a fine branching habit. The health of all the species is good except A. mearnsii which does not grow well on this site.

(c) Site C (650 m.a.s.l.; good soil; clean field condition)
Although the analysis of variance indicates significant differences in height among the treatments, no provenance is taller than the control (local A. mangium, treatment 16) by one LSD. All species are equally vigorous on this fertile lowland site except A. auriculiformis which is generally less vigorous compared with the other species.

(d) Site D (1300 m.a.s.l.; good soil; clean field condition)
Site D represents a unique site because of its high altitude where the minimum temperature is significantly lower than that at the other three lowland sites. The minimum daily temperature is 15°C compared with over 20°C on the lowland sites.

On this highland site, A. mearnsii is most impressive, outperforming the control A. mangium (treatment 16) by two LSD at P < 0.01. The only other species which is significantly more outstanding is A. crassicarpa from Wemenever, PNG (treatment 7). It is taller than the control by one LSD. And except for one provenance of A. auriculiformis (treatment 6), the rest of the species and provenances are not significantly worse or better than A. mangium. On this cool highland site, the height growth of the Acacia species apart from A. mearnsii is generally slower than on the lowland.

Discussion
Fig. 5 and Table 4 depict the mean heights of the five Acacia species on the four sites. The magnitude of the genotype-environment interaction is estimated by the analysis of variance (see Table 5). The analysis shows that both the provenance and site difference are highly significant. Furthermore, the provenance and site interaction is also shown to be highly significant. Thus, the provenance differences are significantly affected by the site differences. Over the series of four sites, the best height growth of all species, except from A. mearnsii, is attained at site C. On this lowland site with deep soil and a good ground preparation, all species are equally vigorous. However, on the other 2 lowland sites (site A and B) where the initial field condition is more hostile, great differences in height growth are shown by the species. On these difficult sites, A. auriculiformis, A. crassicarpa and A. aulacocarpa are significantly more vigorous than the A. mangium, with the greatest differences recorded at site B. On this rocky site with shallow, sandy soil and lalang infestation, A. crassicarpa is taller than the A. mangium by an average of 73% while A. aulacocarpa and A. auriculiformis are 45% and 23% taller respectively.
Figure 5. Species mean ht at the age of 1 year on the 4 sites.

Table 4
Species mean height (m) on the 4 sites at the age of 1 year

<table>
<thead>
<tr>
<th>Site</th>
<th>A. mangium</th>
<th>A. auriculiformis</th>
<th>A. crassicarpa</th>
<th>A. aulacocarpa</th>
<th>A. mearnsii</th>
<th>Overall site mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.7</td>
<td>2.1</td>
<td>2.4</td>
<td>2.2</td>
<td>0.8</td>
<td>2.0</td>
</tr>
<tr>
<td>B</td>
<td>2.2</td>
<td>2.7</td>
<td>3.8</td>
<td>3.2</td>
<td>1.1</td>
<td>2.9</td>
</tr>
<tr>
<td>C</td>
<td>4.2</td>
<td>3.0</td>
<td>4.7</td>
<td>3.6</td>
<td>4.0</td>
<td>3.9</td>
</tr>
<tr>
<td>D</td>
<td>2.0</td>
<td>1.5</td>
<td>2.9</td>
<td>2.0</td>
<td>4.2</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Species mean 2.5 2.3 3.4 2.8 2.5

Table 5
Analysis of variance

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>V ratio</th>
<th>F test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>84.942</td>
<td>3</td>
<td>28.314</td>
<td>14.365</td>
<td>**</td>
</tr>
<tr>
<td>Block</td>
<td>23.652</td>
<td>12</td>
<td>1.971</td>
<td>5.814</td>
<td>**</td>
</tr>
<tr>
<td>Provenance</td>
<td>23.281</td>
<td>10</td>
<td>2.328</td>
<td>6.867</td>
<td>**</td>
</tr>
<tr>
<td>Prov. x site</td>
<td>64.742</td>
<td>30</td>
<td>2.158</td>
<td>6.366</td>
<td>**</td>
</tr>
<tr>
<td>Error</td>
<td>40.686</td>
<td>120</td>
<td>0.339</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6
Regression slope coefficients, b

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Species</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>A. mangium</td>
<td>1.27</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0.87</td>
</tr>
<tr>
<td>5</td>
<td>A. auriculiformis</td>
<td>0.73</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>0.78</td>
</tr>
<tr>
<td>7</td>
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<tr>
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</tr>
<tr>
<td>9</td>
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<td>1.26</td>
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<td>10</td>
<td></td>
<td>1.30</td>
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<tr>
<td>12</td>
<td>A. aulacocarpa</td>
<td>0.99</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>0.82</td>
</tr>
<tr>
<td>14</td>
<td>A. mearnsii</td>
<td>1.03</td>
</tr>
</tbody>
</table>

These three species, therefore, show a greater site tolerance than A. mangium. They exhibit greater capability to withstand poor and shallow soils, and to compete with and dominate the surrounding weeds of lalang and Siam Weed. On these 2 sites, the worst performance is exhibited by A. mearnsii.

On the highland at site D, A. mearnsii is the most outstanding species. This is expected since the species is well adapted to cool moist conditions. At this altitude where the minimum temperature is considerably lower, the rest of the Acacia species generally have a slower height growth than on the lowland.

To relate the performance of each species to variation in the environment, a regression analysis is carried out. The slope coefficients, b, as tabulated in Table 6, show the stability of the species in response to the environmental variation. A. auriculiformis and A. aulacocarpa are the most stable populations and are relatively unaffected by the environment (b ≈ 1). Coupled with a relatively high overall mean response, A. aulacocarpa appears to be most suited to the whole range of sites. A. crassicarpa (except the Wemenever provenance) and A. mangium show a ‘greater than average’ response to the environmental variation. Growth of these two species can be expected to be much better on good sites. However, despite this, A. crassicarpa still performs the best among all the species on the poor site (site B). Although the regression analysis shows that A. mearnsii is of average stability, the species nevertheless requires good soil and clean ground conditions. It also prefers a cooler climatic condition. The slope coefficient of close to unity is perhaps attributed to the fact that the mean performance of the species at each site is regressed on the overall site mean performance.

Of all the Acacia species tested in the trial, the most interesting species appears to be A. aulacocarpa. The species shows good stem form, fine branching habit and strong apical dominance. A. crassicarpa the most vigorous of all species on the lowland sites, has an acceptable form with the stem showing a propensity to bend at the nodes. A. auriculiformis generally has poor stem form. However, some trees of the species, particularly the Iokwa provenance, exhibit good form and a single leader.
Conclusion

A. mangium is well known as a site tolerant species. The results of this trial, however, indicate that three other tropical Acacias i.e. A. aulacocarpa, A. crassicarpa and A. auriculiformis may be even more site tolerant than the A. mangium. They appear to be better adapted to sandy, shallow soils and more capable of competing with the lalang (Imperata cylindrica) and Siam Weed (Eupatorium odoratum). These three species, therefore, show great potential for rehabilitating rocky ground and poor grassland sites, an important role in the humid tropics.

REFERENCE

GMELINA ARBOREA IN NIGERIA

By J. O. ADEGBEHIN*, J. O. ABAYOMI** and L. C. NWAIGBO**

SUMMARY

Gmelina arborea Roxb. is the most commonly planted exotic tree species in Nigeria and, at the end of 1986, over 100,000 ha of plantations of the species have been established. Its growth is particularly promising in the rain-forest and derived savanna zones where most of these plantations are found. The pressing need at present is to supply pulpwod to the pulp and paper mills. In the future the species may be expected to meet several other uses. Site characteristics are given for the areas where the species is raised. Its growth rate and management is discussed.

RÉSUMÉ

Gmelina arborea Roxb. est l'essence exotique la plus fréquemment plantée en Nigeria et, à la fin de 1986, plus de 100,000 ha de plantations de l'essence ont été installés. Sa croissance est particulièrement intéressante dans les zones de forêt dense humide et de savane de dégradation, où se trouvent la plupart des plantations. Actuellement, le besoin urgent est de fournir du bois de trituration aux usines de pâte. Dans l'avenir l'essence pourrait être exigée de servir plusieurs autres besoins. Les caractères de site sont donnés pour les régions où l'essence est cultivée. Son taux d'accroissement et son aménagement sont discutés.

General Background

Gmelina arborea Roxb., which belongs to the family Verbenaceae and is known as Yemane (Burma), Gumhar (India), Gamar (Bangladesh), is native to the moist forests of India, Bangladesh, Sri Lanka, Burma and most of Southeast Asia and Southern China. It has been on trial as an exotic tree species in many tropical countries and commercial plantations are now found in Brazil, Gambia, Sierra Leone, Ivory Coast, Malawi, Malaysia, Philippines, etc. Its site requirements are less demanding compared with those of Tectona grandis which belongs to the same botanical family. It could thrive in several areas where many other species have failed (Onweluzo, 1973). It is generally noted for the ease with which it can be established, its early vigorous growth, its ability to suppress weeds, and the readiness with which it coppices to give the second and subsequent rotations (Lamb, 1968; Greaves, 1979). An additional advantage lies in its use in the taungya system (agro-silvicultural practice) where, at first, it is inter-grown with some agricultural crops, thereby reducing the problem of land hunger and lowering costs of both plantation establishment and food production (Agbede and Ojo, 1979).

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** Forestry Research Institute of Nigeria, P.M.B. 5054, Ibadan, Nigeria.
Introduction of the Species to Nigeria

*Gmelina* is believed to have been first introduced into Nigeria, from India, as early as the year 1900, although the oldest plantation recorded was that of Olokemeji Forest Reserve, near Ibadan, established in 1929 (Anon, 1965); other plantations were later raised in 1936 in Ilorin Native Authority Forest Reserve. In the mid-forties, large scale planting of the species was undertaken in many parts of the country, especially Enugu and Onitsha (Anambra State), Umuahia (Imo State), Obubra, Ikom and Ogoja (Cross River State), Okwesan and Auchi areas (Bendel State). Nowadays, almost all the 19 States of the country have *Gmelina* plantations.

As at the end of 1977, pure *Gmelina arborea* stands accounted for about 48,000 ha representing about 37% of all the plantation area established in the Southern States of Nigeria, (Fig. 1 & Table 1). The total area of *Gmelina* plantations established in the country up to 1983 is given as 90,000 ha (Anon, 1984) as reported by Enabor (1986). Based on the data on additional plantings, the total area established up to 1986 is estimated as 120,000 ha. The rate of planting of the species in the Southern parts of the country coupled with its rapid growth rate in most areas led Ball (1978) to predict that the greater bulk of the future wood production in the high forest zones would come from *Gmelina* (Table 2).

Growth Rate

Although *Gmelina arborea* thrives in many parts of the country, its best performance is in the rain-forest and derived savanna zones (vegetation type classification, Keay, 1959) and detailed growth studies of the species have been restricted to these areas. Why the species used to attract the attention of many foresters in Nigeria is that, given the right
Table 1
Total area of plantations (ha.) in the Southern States of Nigeria by species and year of planting*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Gmelina arborea</em></td>
<td>1,404</td>
<td>4,377</td>
<td>5,345</td>
<td>20,930</td>
<td>7,361</td>
<td>9,162</td>
<td>48,579</td>
</tr>
<tr>
<td><em>Tectona grandis</em></td>
<td>358</td>
<td>1,634</td>
<td>5,411</td>
<td>12,705</td>
<td>4,164</td>
<td>2,857</td>
<td>27,123</td>
</tr>
<tr>
<td><em>Tectona / Gmelina</em></td>
<td>190</td>
<td>1,349</td>
<td>2,095</td>
<td>1,838</td>
<td>—</td>
<td>—</td>
<td>5,475</td>
</tr>
<tr>
<td><em>Gmelina mixture</em></td>
<td>204</td>
<td>657</td>
<td>80</td>
<td>85</td>
<td>—</td>
<td>—</td>
<td>1,026</td>
</tr>
<tr>
<td><em>Tectona mixture</em></td>
<td>1,531</td>
<td>2,062</td>
<td>1,646</td>
<td>5,323</td>
<td>607</td>
<td>510</td>
<td>11,679</td>
</tr>
<tr>
<td><em>Nauclea diderrichi</em></td>
<td>585</td>
<td>337</td>
<td>1,451</td>
<td>5,952</td>
<td>839</td>
<td>916</td>
<td>10,080</td>
</tr>
<tr>
<td><em>Nauclea / Meliaceae</em></td>
<td>5,813</td>
<td>1,883</td>
<td>4,867</td>
<td>2,311</td>
<td>643</td>
<td>500</td>
<td>16,017</td>
</tr>
<tr>
<td><em>Terminalia species</em></td>
<td>86</td>
<td>635</td>
<td>1,384</td>
<td>1,761</td>
<td>865</td>
<td>916</td>
<td>5,617</td>
</tr>
<tr>
<td>Other hardwood species</td>
<td>839</td>
<td>341</td>
<td>225</td>
<td>1,323</td>
<td>566</td>
<td>1,760</td>
<td>5,054</td>
</tr>
<tr>
<td>Other mixtures</td>
<td>99</td>
<td>308</td>
<td>80</td>
<td>271</td>
<td>75</td>
<td>—</td>
<td>1,033</td>
</tr>
<tr>
<td><em>Pinus caribaea</em></td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>49</td>
<td>198</td>
<td>360</td>
</tr>
<tr>
<td>Total (ha.)</td>
<td>11,109</td>
<td>13,583</td>
<td>22,784</td>
<td>52,548</td>
<td>15,318</td>
<td>16,981</td>
<td>132,323</td>
</tr>
</tbody>
</table>


Table 2
Yields from existing and those expected from future plantations in Southern parts of Nigeria (in thousand cubic metres)*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Gmelina</em> sawn-timber</td>
<td>1,281</td>
<td>5,099</td>
<td>7,282</td>
<td>7,282</td>
<td>7,282</td>
<td>7,282</td>
</tr>
<tr>
<td><em>Gmelina</em> pulpwood</td>
<td>2,665</td>
<td>13,285</td>
<td>20,264</td>
<td>21,846</td>
<td>21,846</td>
<td>21,846</td>
</tr>
<tr>
<td><em>Tectona grandis</em> (Teak)</td>
<td>27</td>
<td>396</td>
<td>1,376</td>
<td>3,458</td>
<td>5,219</td>
<td>10,399</td>
</tr>
<tr>
<td>Teak mixture</td>
<td>—</td>
<td>192</td>
<td>1,052</td>
<td>1,969</td>
<td>3,460</td>
<td>6,908</td>
</tr>
<tr>
<td><em>Opepe (Nauclea diderrichi)</em> mixture</td>
<td>—</td>
<td>192</td>
<td>1,052</td>
<td>1,969</td>
<td>3,460</td>
<td>6,908</td>
</tr>
<tr>
<td><em>Terminalia spp.</em></td>
<td>97</td>
<td>622</td>
<td>1,737</td>
<td>2,250</td>
<td>2,250</td>
<td>2,250</td>
</tr>
<tr>
<td>Other hardwood spp.</td>
<td>34</td>
<td>145</td>
<td>318</td>
<td>896</td>
<td>1,321</td>
<td>1,976</td>
</tr>
</tbody>
</table>

* Data source: Ball (1978).
soil types and climatic requirements, it grows faster than many other plantation species. In some of these favourable areas, it gives about one and half to over twice the yield of *Tectona grandis*. As one moves to drier areas than the derived savanna zone, the growth rate of *Gmelina* generally decreases across the other vegetation zones. However, in the remaining parts of the savanna region (viz: the Northern Guinea, Sudan and Sahel zones), other species such as eucalypts, pines, *Azadirachta indica* (Neem), *Acacia* spp etc perform better than *Gmelina* (Adegbehin, 1980 & 1986) and are preferred.

Among the earliest estimates of yield from *Gmelina arborea* in Nigeria were those recorded by Chittenden *et al* (1964). The volumes given, which were regarded as tentative and are not reported for particular locations, were given according to the following soil types in the derived savanna zone of the country.

- Poor sandy soils — 84 m$^3$/ha at age 12
- Good clay or laterite soils — 210 m$^3$/ha at age 12
- Most favourable savanna sites (best sites) — 252 m$^3$/ha at age 10
(All volumes were underbark to 7.5 cm top diameter)

<table>
<thead>
<tr>
<th>Study area</th>
<th>State</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Vegetation zone (Keay, 1959)</th>
<th>Soil type</th>
<th>Annual rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omo</td>
<td>Ogun</td>
<td>7° 00' N</td>
<td>4° 20' E</td>
<td>Rain-forest</td>
<td>Ferruginous tropical soils</td>
<td>Min.* 1500 Max.* 2000</td>
</tr>
<tr>
<td>Ubiaja</td>
<td>Bendel</td>
<td>6° 38' N</td>
<td>6° 25' E</td>
<td>Derived savanna</td>
<td>Red ferralitic soils</td>
<td>Min., 1500 Max., 2000</td>
</tr>
<tr>
<td>Emu</td>
<td>Bendel</td>
<td>6° 30' N</td>
<td>6° 35' E</td>
<td>Derived savanna</td>
<td>Hydromorphic soils</td>
<td>Min., 1500 Max., 2000</td>
</tr>
<tr>
<td>Akpaka</td>
<td>Anambra</td>
<td>6° 15' N</td>
<td>6° 48' E</td>
<td>Derived savanna</td>
<td>Hydromorphic soils</td>
<td>Min., 1500 Max., 2000</td>
</tr>
<tr>
<td>Mamu</td>
<td>Anambra</td>
<td>6° 10' N</td>
<td>7° 15' E</td>
<td>Derived savanna</td>
<td>Red ferralitic soils</td>
<td>Min., 1500 Max., 2000</td>
</tr>
<tr>
<td>Ubibia</td>
<td>Imo</td>
<td>5° 28' N</td>
<td>7° 36' E</td>
<td>Rain-forest</td>
<td>Red ferralitic soils</td>
<td>Min., 2000 Max., 2500</td>
</tr>
<tr>
<td>Ukpom-Bende</td>
<td>Imo</td>
<td>5° 33' N</td>
<td>7° 35' E</td>
<td>Rain-forest</td>
<td>Red ferralitic soils</td>
<td>Min., 2000 Max., 2500</td>
</tr>
<tr>
<td>Awi</td>
<td>Cross-River</td>
<td>4° 53' N</td>
<td>8° 02' E</td>
<td>Rain-forest</td>
<td>Red ferralitic soils</td>
<td>Min., 2000 Max., 3000</td>
</tr>
<tr>
<td>Oforachi</td>
<td>Benue</td>
<td>7° 05' N</td>
<td>6° 45' E</td>
<td>Derived savanna</td>
<td>Hydromorphic soils</td>
<td>Min., 1250 Max., 1500</td>
</tr>
<tr>
<td>Jebba</td>
<td>Kwara</td>
<td>9° 07' N</td>
<td>4° 55' E</td>
<td>Southern Guinea savanna</td>
<td>Hydromorphic soils</td>
<td>Min., 1000 Max., 1250</td>
</tr>
<tr>
<td>Lafiagi</td>
<td>Kwara</td>
<td>8° 53' N</td>
<td>5° 24' E</td>
<td>Southern Guinea savanna</td>
<td>Ferruginous tropical soils</td>
<td>Min., 1000 Max., 1250</td>
</tr>
</tbody>
</table>

* Refers to the minimum and maximum values.
** Data source: Abayomi and Nwaigbo (1985).
The productivity study on *Gmelina* by Greaves (1972), carried out in Ishan and Etsako Divisions of the Mid-Western State (now Bendel State), included the construction of site index curves and yield tables for the species. The areas covered by the study included the rainforests, derived savanna, savanna woodland and shrub savanna. The five site classes constructed included I (a top height of 27m at a reference age of 10 years), II (23 m), III (19 m), IV (15 m) and V (11 m). The mean annual increment (M.A.I.) was found to reach its peak at the ages of about 15, 15, 14, 13 and 12 years with an underbark total volume production (TVP), to 7.5 cm top diameter, of about 471, 291, 169, 98 and 55 m³/ha for site classes I–V respectively.

In a further growth study, Abayomi (1981) computed yield figures for the species at Awi Forest Reserve, a typical rain-forest area in the Cross River State, and marked out five site quality classes. He noted that the M.A.I. reached its peak at the age of 8 years for all the classes and that this peak was attained with an underbark TVP of about 319, 269, 227, 189 and 158 m³/ha for site quality classes I–V respectively. The age at which maximum M.A.I. is reached varies according to differing site characteristics. At Subri River Forest Reserve in Ghana, for the seven site classes constructed for the species, *viz: I* (34 m), *II* (30 m), *III* (26 m), *IV* (22 m), *V* (18 m), *VI* (14 m) and *VII* (10 m) at a reference age of 10 years (Anon, 1982), the M.A.I. reached its peak between the ages of 3–8 years as compared with 8 years for Awi Forest Reserve (Abayomi, *loc. cit.*) or the range of 12–15 years for Bendel State (Greaves, 1972). However, consideration of the site index curves given by Greaves, would suggest that the maximum M.A.I. should be reached at an earlier age on better sites.

The site productivity classes for Awi, given by Abayomi, had, at age 10, top heights of 31.5, 29.3, 27.1, 24.8 and 22.6 m for quality classes I–V respectively, suggesting that the best site at Awi is a class higher than the best site of the set of curves for Bendel by Greaves while the poorest site at Awi (22.6 m at age 10) compares with site class II (23 m at age 10) of the same set of curves. As already noted by Abayomi (1974), most of the plots at Nimbia and Dogon Kurmi, the derived savanna pocket neighbouring the Jos Plateau but within Kaduna State, fall within site class III (19 m at age 10).

In another study, Abayomi and Nwaigbo (1985) analysed the growth data for *Gmelina arborea* from eleven localities in the rain-forest and savanna zones of Nigeria (some of the site characteristics of which are given in Table 3) and ranked these areas in descending order based on their relative levels of top height, basal areas and volume figures resulting in the following yield class ratings:

- Most of the plots (over 67%) at Emu and Oforachi. **Yield Class Rating I**
- Most of the plots at Awi, Ukpom-Bende, Akpaka, Ubibia and Omo. **Yield Class Rating II**
- Most of the plots at Ubiaja, Mamu, Jebba and Lafiagi. **Yield Class Rating IV**

When the ranking of these areas is examined in relation to the site characteristics (Table 3), Emu and Oforachi, with most plots in Yield Class Rating I, lie within the derived savanna zone which generally has a lower rainfall than the rain-forest areas. Hence it can be concluded that, apart from rainfall, the soil type is another factor determining the site quality of the species. As pointed out by Greaves (1979), *Gmelina* prefers a loamy clay soil with a high proportion of exchangeable bases. When the rainfall is not limiting, the hydromorphic soils therefore appear to satisfy this requirement better than other soil types listed in Table 3. However, as the species grows in many parts of the country, it clearly adapts to most soil types. Poor soil conditions in Sierra Leone were said to limit the life span to 15–18 years (Lamb, 1968), but in Nigeria stands have exceeded 25 years of
age without any appreciable death of the trees apart from the occasional occurrence of self-thinning.

**Utilisation**

The most pressing need for *Gmelina* in Nigeria is for the supply of pulpwood to the pulp and paper mills either established or planned for the different parts of the country. The *Gmelina* plantations in Awi Forest Reserve near Calabar, Cross River State, are earmarked to serve as a source of raw materials for the pulpmill at Oku-Iboku. The yield studies of the species in Awi Forest Reserve (Abayomi, 1981) show that the plantations can satisfy the estimated pulpwood requirements (Ball, 1978) in terms of both rotation and total volume production. Considering the growth of the species on an average site (site quality III), a rotation of 7–8 years appears suitable for managing the pulpwod plantations with an estimated underbark total volume production of 197–227 m$^3$/ha respectively. The *Gmelina* plantations at Omo and Oluwa Forest Reserves are expected to supply the proposed pulpmill at Iwopin in Ogun State while the pulp and paper mill at Jebba is already having an intake of 12-year old *Gmelina* from Mokwa (yield class rating IV). As *Gmelina* plantations can yield a good rate of return if raised for pulpwood private individuals might be encouraged to invest in forestry crops. It is suggested that *Gmelina* plantations could be harvested for pulpwood after 5–10 years with an estimated rate of return of 12–20% (Enabor, 1986).

The peeling and gluing properties of Nigerian-grown *Gmelina* wood have been investigated; logs produce good quality veneers which glue well when used for plywood (Badejo, 1978). The African Timber and Plywood (A.T. & P), Sapele, has been raising plantations of the species for this purpose. *Gmelina* is used for match-splints and match boxes, and is grown for pit-props for the coal-mines at Enugu. It is used as fuelwood in some parts of the country and in Sokoto State, where the species may fail to reach timber size, this may be its major use.

*Gmelina* wood is in the medium strength class according to the Forestry Research general classification scheme (Anon, 1965); it works easily with hand and machine tools, is easy to saw and nails well. At present, sawnwood from the species is not common in the market as the Forestry Authorities have not been issuing timber licences to sawmillers to operate in Government-owned plantations and there are few stands that are privately owned. Even when licences are issued and logs are extracted, there is a lot of waste, especially from forked or crooked trees which can only produce short logs that will not meet the 3.7 m-standard board length.

A major problem in the management of *Gmelina* plantations in Nigeria is that most stands remain unthinned. Apart from a lack of resources to carry out the thinning operation, until the recent demand by the pulp and paper mills, thinnings had no market other than for fuelwood which fetched very low prices. Even now, where plantations are far from the pulp mills, there is still no profitable market for thinnings. A solution to this problem is for the Government to encourage the setting up of integrated wood-using industries where *Gmelina* is extensively planted, with the smaller and mis-shapen logs used by pulp or particle board mills and the larger logs converted to sawnwood or plywood.

**Conclusions**

The most important use for *Gmelina arborea* at present in Nigeria is to supply the pulp and paper mills established in different parts of the country. However, at the rate at
which the indigenous tree species are being depleted and the rate at which *Gmelina*
plantations are being established, *Gmelina* timber can be expected to be used for many
more purposes in Nigeria in the future. Proper management of the plantations, in terms
of thinning and pruning (where necessary), is recommended in order that the trees have
the desirable timber properties to meet these varied uses. Government should also
encourage the establishment of integrated wood-using industries in some of the large
*Gmelina* growing areas to ensure maximum returns from the plantations.

**Acknowledgements**

As this paper is mostly a review on the findings about the species over some years, the
contributions offered by the various authors referred to in the text are fully appreciated.

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192A.


**In vitro** PRODUCTION OF ROOTED PLANTLETS FROM INDUCED INTERFASCICULAR BUDS AND OTHER EXPLANT MATERIAL FROM *PINUS OOCARPA* (SCHIEDE)

By Janette E. INGLIS

**SUMMARY**

Interfascicular and fascicular buds were induced by spray applications of BAP at two levels to ortets of *Pinus oocarpa*. Both types of bud were transferred to agar medium and cultured *in vitro*. The elongation of these buds was measured to determine whether BAP applications retarded elongation of the shoots *in vitro*. Stem buds were not retarded at either level. Fascicle buds treated with 100 mg/l elongated more readily than those treated with 200 mg/l, at this level there was virtually no response.

The elongated shoots were transferred to root induction medium, followed by root elongation medium including a soluble NPK propriety fertiliser, where rooting was achieved. After transplanting to *in vivo* conditions, establishment was assessed of the plantlets using a comparison of two types of growing-on media. A second comparison included plantlets from *in vitro* with trimmed roots and untrimmed roots. Better establishment developed from those with trimmed roots.

**Introduction**

Further experiments have been carried out as an extension of recent work on the effects of some growth substances on the promotion of interfascicular shoots in *Pinus caribaea* (Morelet) (Inglis, 1984). Induced buds were transferred to *in vitro*, thus forming new plantlets. The aims were not only to multiply propagules from the ortet by application of BAP (benzylaminopurine) to induce more buds, but to increase shoots from these buds in culture, until they were large enough to be rooted *in vitro* and grown on *in vivo*. Earlier work showing the promise of cytokinin treatment for bud induction in *P. caribaea* (Inglis, 1984) was expanded to include *P. oocarpa*.
The methods used in this experiment to micropropagate induced buds, are a combination of those used at Bordeaux University (David, 1979; David & David, 1977; David & Thomas, 1979). The aims were to reduce the four stages of their nutrient media to only two stages: firstly by inducing buds on the parent plant rather than in vitro and secondly by using a different medium than previously used to promote rooting in vitro. Success would speed up the process and hence reduce costs of large scale production of forestry species. This would be particularly valuable in the production of *P. caribaea* and *P. oocarpa* for re-afforestation programmes in the tropics, with relatively rapid production of selected faster growing clones possessing better timber quality. Due to the rapid destruction of tropical forest regions, replanting is a major priority whether for managed timber production or for ecological reasons.

**Bud Induction and Transfer to in vitro Culture**

Mainstem and fascicle buds were induced on ortets sprayed with BAP (Table 1). In the absence of BAP, neither stem nor fascicle buds were produced. After induction, interfascicular buds were left to develop until 5mm-1 cm. in length before transfer to in vitro culture. BAP was included in the growth medium to encourage the buds to multiply into several shoots for subculturing. There was no difference in the number of stem buds formed with low or high levels of BAP. In contrast, however, many more fascicle buds were formed when BAP was applied at 200 rather than 100mg l (p < 0.001).

The induced buds were transferred directly to elongation medium, thus dispensing with the bud induction medium stage. Interestingly, buds took about the same time to be induced in vitro as they did on the ortet i.e. 21 days and 18–20 days respectively.

A small trial (using 180 plants) was conducted to find whether bud induction of fascicles in vitro could be increased by priming the ortet with BAP before transferring the fascicles to bud induction medium. The results showed that the percentage bud induction of fascicles by this treatment was 78% (SE + 4.4%) compared with only 40% (SE + 5%) bud induction in fascicles from an untreated ortet.

**Table 1**

Mean number of buds produced per tree. Following treatment of ortet at 5 day intervals for 1 month.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Stem buds</th>
<th>Fascicle buds</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>BAP 100 mg/l</td>
<td>1.71</td>
<td>3.59</td>
<td>10</td>
</tr>
<tr>
<td>BAP 200 mg/l</td>
<td>1.70</td>
<td>5.99</td>
<td>10</td>
</tr>
<tr>
<td>SE difference 18 d.f</td>
<td>0.738</td>
<td>0.499</td>
<td></td>
</tr>
</tbody>
</table>

(Excluding control)

**Elongation of Shoots in Culture**

The medium used for elongation of shoots in vitro was the basic formula for bud induction medium but with sucrose reduced to 20g/litre, and the addition of 20g/litre of activated charcoal to remove any toxins present in the agar or aromatic waste products exuded by cultured tissues and to prevent browning of the tissue.
In addition to the elongation medium, 10ml/litre of de-proteinised coconut water was added following the suggestion of Konar and Singh (1980) who obtained good results with this in studies on *Pinus wallichiana*.

Shoots take six to eight weeks to elongate sufficiently for transfer to the rooting stage. An experiment was conducted using explant material from ortets treated with BAP at either 0, 100 mg/litre or 200 mg/litre.

Induced buds were removed from BAP-treated plants and transferred to elongation medium including de-proteinised coconut water. The experimental design included 30 fascicle and 30 stem buds, from each treatment. The buds were approximately 5 mm in length at transfer.

**Table 2**

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>Type of bud</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fascicle</td>
<td>Control (no treatment)</td>
</tr>
<tr>
<td>2</td>
<td>Stem</td>
<td>Control (no treatment)</td>
</tr>
<tr>
<td>3</td>
<td>Fascicle</td>
<td>Ortet treated BAP 100 mg/litre</td>
</tr>
<tr>
<td>4</td>
<td>Stem</td>
<td>Ortet treated BAP 100 mg/litre</td>
</tr>
<tr>
<td>5</td>
<td>Fascicle</td>
<td>Ortet treated BAP 200 mg/litre</td>
</tr>
<tr>
<td>6</td>
<td>Stem</td>
<td>Ortet treated BAP 200 mg/litre</td>
</tr>
</tbody>
</table>

There were 15 test tube racks (blocks) in the experiment. Each contained 12 slots and two replicates of each of the 6 treatments were arranged at random within each rack.

Once the shoots are inserted into bud induction medium they are kept under continuous light at 28°C while on shoot elongation medium they are kept at 25°C. These conditions also apply for apical tip material.

**Proportion of Buds which Elongated**

Each observation is the number of buds which elongated out of thirty replicates. A Chi-squared test was used to compare the proportions of induced stem and fascicle buds which grew in each of the three BAP treatments.

Stem buds and fascicle buds responded very differently to increasing amounts of BAP (Figure 1) Nearly all the stem buds grew whatever the level of BAP. However fascicle buds only grew when BAP was at 100 mg/litre, there being virtually no response to either no BAP or to 200 mg/litre (= interaction = 41.7, 2df, \( P < 0.001 \)) interaction = 41.7, 2df, \( P < 0.001 \)). It would seem therefore, that 100 mg/litre is an optimum level.

**Length of Bud Elongation**

No fascicle buds elongated in the absence of BAP and only two did so at 200 mg/litre BAP so these treatments have been excluded from the analysis of the length of bud elongation. There was no significant difference between the mean elongation of stem buds and fascicle buds at 100 mg/litre. However, considering stem buds only, the doses of BAP give differing amounts of elongation (\( p < 0.01 \)). There was a linear trend of less growth with more BAP (\( p < 0.01 \)).
Figure 1  The proportion of stem buds and fascicle buds which elongated at 3 levels of BAP

Table 3
Mean elongation/bud (mm) of those buds which showed elongation

<table>
<thead>
<tr>
<th>Bud Type</th>
<th>0</th>
<th>BAP mmg/litre</th>
<th>SE difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem</td>
<td>28.2</td>
<td>22.5</td>
<td>18.3</td>
</tr>
<tr>
<td>Fascicle</td>
<td>—</td>
<td>29.1</td>
<td>—</td>
</tr>
</tbody>
</table>

Rooting in vitro

In previous micropropagation trials, the in vitro rooting of elongated shoots of P. caribaea and P. oocarpa, was not consistently achieved. A root induction medium was used followed by subculturing into root elongation medium in an environment of 21°C with a 16 hr photoperiod. Recently it was discovered that rooting was successful on an agar medium when an NPK liquid fertiliser was added. (Woodward, Pers. comm.).

The nutrient was added on this occasion at full strength i.e. 0.5 g/litre. (Total N 10.0%, P 10.0%, K 27.0%, Mg 1.3%, Fe 0.4%, Mn 0.02 mg/kg.), no sucrose or vitamins
were included. After six weeks, most shoots had produced callus and root initials had appeared. They later developed sufficient root for transplanting and weaning from culture.

Before transferring 63 shoots from elongation medium into sterilised fertilised agar medium, they were given a one second basal dip of IBA at 2500 ppm. Further trials are in progress to improve rooting percentages. In earlier attempts NAA (napthaleneacetic acid) was added to the nutrient agar with some success and it was therefore thought that an initial dip of sterile Indol butyric acid might increase rooting.

By the final assessment on 8 January 1986 the ninety five percent confidence limits for the proportion rooting were from 11.8 to 32.5%.

Table 4
Condition of shoots on 8 January 1986. (Eight weeks after transfer to agar medium)

<table>
<thead>
<tr>
<th>Number</th>
<th>%</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>15.9</td>
<td>necrosis but no fungal or bacterial infection</td>
</tr>
<tr>
<td>14</td>
<td>22.2</td>
<td>Rooted</td>
</tr>
<tr>
<td>21</td>
<td>33.3</td>
<td>Callused</td>
</tr>
<tr>
<td>18</td>
<td>28.6</td>
<td>Survived but no callus or rooting</td>
</tr>
<tr>
<td>63</td>
<td>100</td>
<td>Total</td>
</tr>
</tbody>
</table>

By the final assessment on 8 January 1986 the 95% confidence limits for the proportion rooting were from 11.8 to 32.5%.

Weaning Rooted Plantlets from in vitro to Conventional Growing Conditions

Roots produced in vitro are very fleshy and easily broken at the transplanting stage. Also, there is a large amount of callus at the point where the roots emerge. This is believed to inhibit root development. It was suggested (H. Wainwright, pers. comm.) that it may be better to cut back the roots before transplanting to stimulate better root formation. To test this hypothesis, 50% of rooted plants from in vitro were transplanted with their roots cut back and 50% with uncut roots. The plants were weaned from culture in a growth cabinet at the same photoperiod and temperature regime as for rooting. They were given an overhead spray of distilled water plus NPK liquid fertiliser as used in the agar rooting medium for healthy growth. It is essential at all times to maintain humidity and moist media surrounding the root system. A plastic cover was placed over the plants to maintain a humid environment.

The two types of material used for transplanting were GRODAN an inert material made from rockwool used by commercial growers together with nutrient film technique and JIFFY SEVENS; small peat blocks encased in paper netting.

Plantlets transferred to Grodan blocks have shown 80% establishment irrespective of whether their roots were cut. Plantlets transferred to the peat blocks showed poorer establishment with plants that had cut roots giving 50% and those with intact roots 3% establishment.
Table 5
Number established out of 30 rooted plantlets

<table>
<thead>
<tr>
<th></th>
<th>GRODAN</th>
<th>JIFFY SEVENS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Established</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td>Not Established</td>
<td>6</td>
<td>14</td>
</tr>
</tbody>
</table>

Discussion

This study has shown that there is an advantage of inducing buds on the ortet therefore the number of different stages of the micropropagation process could be reduced from six to four, by induction of buds on the ortet by sprays of BAP instead of inducing buds in agar.

Transference of the induced buds directly onto shoot elongation medium and measuring the subsequent effect of two levels of BAP and control has shown that there is retarded elongation following applications of 200 mg/1 of BAP at the bud induction stage. More elongation developed from buds induced by applications of BAP at 100 mg/1.

Subculturing of elongated shoots into agar with soluble fertiliser plus an IBA quick dip achieved rooting in 6 weeks, whereas previous root induction media had little effect. The roots produced were hairless fleshy and brittle but functional. When transplanting to in vivo they were inclined to break off. If they did remain intact they died off to re-develop more fibrous roots. By trimming the roots developed in vitro before establishment in vivo a more functional fibrous root system formed although the root initiation developed in vitro. The use of a soluble NPK fertiliser for rooting is an economic and quick method. It is suggested that plantlets could be produced in a total of 12 weeks: 6 weeks for elongation and 6 weeks for rooting.

Acknowledgements

I should like to thank Dr. Trudy Watt for guidance and help with experimental design and analysis, Dr. Roger Hall and Dr. Richard Barnes for discussion and Dr. Steve Woodward for comments on rooting techniques in vitro.

REFERENCES


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REVIEWS

Requests for any publications received or noted below must be addressed to the publishers and NOT to the Association.

Southern Beeches. A. L. Poole. The botany and ecology of the southern beeches are related to the evidence for continental drift. New Zealand Department of Scientific and Industrial Research Information Series No 162. 168 pp, well illustrated with black and white photographs and line drawings. No price is given.

The book is divided into eight Chapters; the first two deal with the main characteristics of both Fagus and Nothofagus their natural distribution and the history of their botanical discovery. The way the natural distribution of Nothofagus species in the widely separated countries of New Zealand, Australia, Chile, New Caledonia, and New Guinea and fossil Nothofagus in Antarctica has been used as evidence for continental drift, this is described. The relative uniformity of the northern hemisphere Fagus (14 species in total) is contrasted with the variety of the southern Nothofagus (37 species) in which natural hybridisation is common especially in New Zealand.

Chapters 3 to 7 then examine in turn the species found in each of the countries; botanical features are described with drawings of leaf, flower and fruit. The distribution, relationships with climate and the resulting forest types, their ecology, seed production and natural regeneration are discussed and illustrated by numerous black and white photographs. Comparisons are made between the forests of different countries and the influence of man, fire and grazing. Evidence is quoted that Nothofagus is in evolutionary terms a very much older genus than Eucalyptus.

The final chapter describes some of the common characteristics of the various species in different countries and speculates over unanswered questions on the evolutionary history and the migration of Fagus and Nothofagus.

Mention is made of the putative hybrid between *N. menziesii* from New Zealand and *N. obliqua* from Chile that has occurred in Britain (illustrated on P 131; text P 132).

A short list of references, a glossary and an index are included.

This is a readable account of the southern beeches in which readers involved in forestry, botany, geology, geography and ecology will find much of interest; those with a specialised interest will find this an excellent introduction to the subject.

R. E. Crowther

---

"100 Malaysian Timbers", from the Malaysian Timber Industry Board, Kuala Lumpur.

This is a major book on Malaysian woods. It is excellently produced with a colour plate of each timber and flat sawn and quarter sawn plates for a few.

Timbers are grouped in the book into Heavy, Medium and Light Hardwoods and Softwoods (conifers). Pictures of articles made from each timber group precede the section on the group.

After an introduction describing data sources and property classification systems used, each timber is allocated one double page giving standard and botanical names, a few lines on distribution, a short general description of appearance, grain and anatomy, physical properties (including density, shrinkage, seasoning and recommended kiln schedule), mechanical properties (MOE, MOR, Compression and Shear), Durability, Treatability, Working properties (planing, boring, turning, nailing) and uses.
Information given is concise and, in view of the space available, quite comprehensive and sufficient to give useful guidance for practical use of the timber.

The colour plates are very useful in giving an idea of the general appearance of the wood, something which is almost impossible to describe adequately in words.

Variations in properties are, to some extent, described for colour, and physical and mechanical properties, but could be rather more informative.

Distribution information is rather vague and not of great assistance in determining which species may or may not be available in exportable quantities.

Botanical names often embrace a whole genus or several species and in the case of a wood with the standard name “Penarahan” the botanical name is listed as “Species of Myristicaceae”. This situation seems unsatisfactory as there must be a wide range of wood properties within many genera and certainly within a whole family.

The book is, however, a very useful and very well illustrated guide to Malaysian woods which should be of great use to the Timber Trade and instrumental to the better marketing and export of new species.

R. A. Plumptre

Commonw. For. Rev. 67(2), 1988


The familiar orange ‘Flora of Bhutan, including a record of plants from Sikkim’ has an established place as today’s standard. It is the first Flora to cover exclusively Bhutan and the nomenclature is up to date. This contrasts with the old handbooks covering the whole Indian subcontinent (by Troup, Gamble, Brandis _et al_) which were previously the main source of reference in the various forestry libraries in Bhutan.

The first part of Volume 1 includes a handy overview of the history of the botanical explorations, a practical classification of the vegetation and an outline of the phytogeography. Three parts of the first of the planned 3 Volumes have now been published (in 1983, 1984 and 1987 respectively), each part being almost 50% thicker than the previous one. For each family of flowering plants clear keys lead to the genera and from there to species or groups of similar species. Each species has its synonyms, local names, morphological descriptions, indications on the distribution, supplementary information and sometimes illustrations, all provided in a lucid way.

The authors are ambiguous when elaborating on the aims of the Flora. On page 6 for example: ‘Although primarily an identification manual of E Himalayan plants and a checklist of the Bhutanese flora with up-to-date nomenclature ...’, but then again on page 32: ‘The Flora of Bhutan is written primarily for foresters ...’.

I would fully agree with the former, less so with the latter. For foresters who are not specialised in botany the flora is probably of limited practical value, and the old handbooks mentioned above therefore likely to remain important complements.

The morphological descriptions are of a rather technical botanical nature, with little or no attention to field characteristics such as growth habit, characteristics of bark and sapwood, or winter features for deciduous trees. The clear illustrations are
REVIEWS

unfortunately very sparse with major emphasis on floral characteristics. An indication of scale would have been handy with the illustrations.

Information is generally very concise but at times incomplete. Taking for instance the common oak *Quercus semecarpifolia* page (79), it will grow much taller than the 25 m mentioned. It becomes shrub-like because of repeated cutting and browsing, the leaves being important for cattle. It also occurs well below 2400 m elevation, and the wood is not only a source of fuel but is also an important substratum for the cultivation of mushrooms.

A glossary of terms is foreseen for the last volume, but would have been practical already in the very first issue, because now one needs a separate botanical glossary. The indices within a volume are not cumulative, therefore it is not possible, for example, to find in the index of part three a species which is treated in part one.

Bearing in mind that at present most forestry activities in Bhutan take place in the coniferous belt, part 1 is by far the most important of the three, covering amongst others the gymnosperms and the dicotyledon families Salicaceae, Betulaceae, Fagaceae and Ulmaceae. Overall, as a forester, I would have preferred more emphasis on trees, and less on typical herb/shrub families such as Crassulaceae, Saxifragaceae, Geraniaceae etc. which receive equal attention.

Finally, may I add the following titles which I did not find in the bibliography and which might be of additional relevance:

6. Troup, R.S. Silviculture of Indian Trees.

P. Laumans

*Commonw. For. Rev.* 67(2), 1988


The book is centred on India, where the author was serving as a member of the Indian Forest Service in the National Wastelands Development Board, having served earlier in the Forest Department in Jammu and Kashmir. However it draws also on a wider review of its subject undertaken at Oxford during postgraduate studies and the resulting combination has produced a book which is both informative and thought-provoking. The subject is the large area of degraded and unproductive land, much of it formerly forest, and the objective suggested by the author is its direct contribution to national economic development and to the alleviation of poverty.

Part I deals briefly with the history and current state of degradation, the needs of local people and industry, and the ongoing programmes of social forestry or rural development to combat problems of drought and desertification. Despite the massive increase in expenditure on such programmes in India from both national and international sources within the past ten years the author concludes that current planting rates are still substantially below the targets needed to meet the demand.
Part II is concerned with afforestation techniques and systems and together with the appendices, giving lists of tree species for various climatic zones in India, with more detailed information on selected species, it forms the bulk of the text. On choice of species questions regarding indigenous versus exotic species, or mixed versus pure plantations receive brief but balanced treatment which should help discourage the mistaken prejudice and generalisation which have recently clouded these issues in India. Such general issues apart the range of climatic conditions, possible species, and techniques for their establishment is so wide that it would be impossible in a book of this length to do more than to explain the important factors to be considered at all stages, concerning site conditions, seed supply, nurseries, planting and maintenance. This the author does well, with a separate chapter dealing with difficult sites, and for many people and organisations outside the forestry profession but now concerned to promote and assist wasteland afforestation the book should serve both as a guide to the technical issues involved and an encouragement to seek further professional guidance where needed.

Some criticisms of social and community forestry programmes in India are referred to briefly in discussing systems of afforestation, and the role of extension services in dialogue with the people in rural communities. However it is in Part III, entitled “Solutions: Policy and Programmes”, that such issues receive fuller treatment. The author reiterates the necessity for wasteland development to meet the needs of poor people, and that while it must aim at economic development rather than purely environmental objectives it must also be concerned with equitable distribution of benefits. The need for both political commitment and popular involvement is stressed and the essential role of land use planning emphasised. These are now familiar principles and it is their translation into effective practice which is commonly deficient. The complexities of Indian history, culture and society, overlying the complexities of climate, soils and vegetation, make it the ultimate proving ground for such efforts, not going back to some ideal ancient village structure or golden age of balance between man and his environment that no longer exist, but forward to new sustainable patterns of development. There can be no single, simple model, other than to ensure that all potentially conflicting elements — different strata in society, local government, women, voluntary organisations (NGO’s) and central government — are positively involved. Some approaches including the possible leasing of wasteland to the landless, tree tenure systems, tree farming cooperatives and self-help groups are reviewed with frank recognition of the legal and practical difficulties to be overcome. The thoughtful and concerned treatment of this section is characteristic of the book as a whole, which contains much of value for all parties concerned in the search for solutions, be they foresters, socio-economists, environmentalists or aid agencies. Read in the same spirit it should help to bring these parties closer together, and closer to what should be their common goal. There are some 90 references and a useful index which enhances the book’s own value as a reference text.
REVIEW NOTES


This is the second of a proposed series of seven reports on a joint project between Wageningen and Suriname Universities entitled ‘human interference in the tropical rain forest ecosystem’. The first report by de Graaf (reviewed in Commonw. For. Rev. 65 (1986) 166) described the CELOS silvicultural system, based on light selective felling followed by refinement. Here the consequences for forest hydrology and nutrient budgets and flows are explored. The rain forests under study grow on a very infertile sandy clay loam. This has degraded to podzol in places where drainage is impeded. It was feared that even selective logging might lead to loss of ecosystem nutrients and degradation of the forest. Detailed measurements over 4 years 9 months of water and nutrients in two adjacent catchments, one logged and one a control, followed by computer modelling allow the description of the hydrology and nutrient status. It is found that the CELOS silvicultural system does not lead to loss of nutrients or have much effect on hydrology. Conversion of the forest to agriculture would be a disaster because decreased evapotranspiration would lead to increased water flow through the soil and to nutrient leaching.

This is a very important and meticulously conducted study. There are very few studies in rain forest anywhere in the world which include measurements of all nutrient pools and all flows between them. For this reason forest ecologists will find here much of great interest. For example, there are slightly more nutrients entering in rainfall than leaving in streamflow and ecosystem nutrients are slowly increasing. It is argued that this is a phenomenon of the present day wet climate, with rain forests clothing the landscape, whereas during the previous drier climate, coincident with the last (high latitude) Glaciation, savannas occurred. These savannas were less able to retain nutrients within the ecosystem and had a lower total nutrient content. For foresters the study is also exemplary. De Graaf in his study developed the CELOS system which did not degrade forest structure or stature, but he could not be sure, especially given the nature of the soils, that human interference might not be damaging nutrient status and hydrology. Poels shows here that all is well. This is exactly the kind of investigation which needs to be conducted in rain forests which are scheduled for production. We need to learn the sustainable level of timber production and to make sure that ecosystem functions are not impaired by such operations. These studies give the lie to those extremists who think that rain forests are so delicate that the only possible course is to lock them up and leave them alone. They show that Mankind has the capacity to discover how nature functions and then devise means to work within bounds to maintain ecosystem processes. What needs to be added to complete the equation is a long term view, and a lack of cupidity — and those are what are most commonly missing.

T.C. Whitmore


This meeting was convened on the 29th/31st March 1987 by the Institute of Chartered Foresters “to consider the attributes of the timber and coniferous and broadleaved
species that are grown in the United Kingdom and the possible markets for them."

The list of delegates shows a very wide ranging and professional gathering from the forestry and grower ranks, but the consuming side representation was very thin on the ground for what had to be a balanced discussion.

Softwood Supply and Demand was covered by Roger Bradley, our CFA chairman, who chartered progress in detail from 1977 onwards. A steady rise in availability had lead to the current position where domestic production of softwoods accounts for 15% of the U.K. Market.

This situation has not been achieved without trauma on the consumption side with a dramatic fall of demand in 1979/80 following the closure of the Bowater and Wiggins Teape pulp mills. This excess has now been corrected with a new pulp mill at Shotton, the O.S.B. Plant at Dalcross and the revitalisation of the U.K. chipboard industry. Further demand will, however, be needed in the 1990's if continued exports are not to be contemplated.

Roger Bradley spends less time on saw logs where demand is clearly less of a problem and states that "overall the demand for sawlogs matches available supply very closely because of the compensating effect of the top diameter level".

He states that as imports account for 85% of the domestic market the level of some wood prices is determined by that of imported timber. His table No. 4, however, indicates that the F.C. log index has recently fallen well behind the Imported Sawn Softwood Index. This indicates to me that the U.K. product is having to buy its way into the market, or alternatively is being aimed more and more to the lower end of the market: clearly this problem needs addressing: Currency fluctuation may be partly to blame.

John Sunley — director of TRADA — in his conclusions, indicates that it will be possible for British Timber to take a small share of the joinery market and an increasing share of the carcassing requirements for the construction industry. This must give British forest owners encouragement for the future.

During the question session Mr. C. Burd said that the obvious market sector for British timber was in construction and that mechanical stress grading was the key to this.

Turning to the Broadleaved Markets, Roger Venables suggested that the future hardwood market should be based on the white hardwoods — beech, ash and sycamore. He emphasised that there is a market for all grades of these species and that they have a growing cycle of 60–80 years, compared with 100–150 years for oak. Mr. Venables shows little enthusiasm for Nothofagus, saying that this specie has no special merit over the traditional native hardwoods.

C. G. A. Latham

Commonw. For. Rev. 67(2), 1988


This, third in the proposed series of seven reports (see Commonw. For. Rev. 65 166) provides yet more excellent and important information to underpin the sustainable utilisation of the Suriname rain forests on the Zanderij Belt which lies between the coastal plain and interior uplands. Like the others, the research was the doctoral work of its author. De Graaf, in the first report, described a polycyclic silvicultural system, CSS, the CELOS Silvicultural System. Here this is refined, based on a more recent major experiment plus some ancillary ones. Selective logging if properly done does not inflict
unacceptable damage on the forest but felling sizes need to be carefully prescribed. Forest recovery is slow and increment needs to be boosted by silvicultural treatment, judicious poison girdling of certain trees by careful determined limits, and climber cutting. Modifications in the original prescriptions are proposed, for example to avoid removing trees from areas without commercial species. These practical analyses are set in the broader context of the necessity to maintain ecosystem functioning, for example not to remove food sources for fruit eating animals whose role is as dispersers.

This report and its companions should be essential reading for all rain forest ecologists, silviculturists, managers and conservationists.

T.C. Whitmore

Commonw. For. Rev. 67(2), 1988


This is a document overflowing with statistics with only a trickle of narrative. Almost certainly a must for the statisticians of Ottawa and the FAO, it also represents a compendium of information for those seeking statistics on a wide range of related topics.

Those with interests outside Canada should turn to Sections VII, VIII and IX which contain a wealth of interesting economic tables on Canadian Financial Statistics, Economic Indicators and related data on world forestry.

In general, all the figures you want to know about forestry in Canada should be in this publication and also a lot else.

This publication is obtainable free from the Canadian Forestry Services,
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RESEARCH NOTES

Remission in Yellowing Disease of Coconut Palm by M. Jalaluddin (Dept. of Botany, University of Karachi and S. A. Jamil Khan (Crop Disease Research Institute, University Campus, Karachi).

Coconut palm (Cocos nucifera), an oil yielding plant, grows abundantly in the city of Karachi (Pakistan). The soil in the districts of Karachi is sandy loam, pH 7 and the weather for most of the year is hot and moist. On account of the economic value of coconut oil, coconut nurseries and plantations have sprung up on a large scale during the last ten years.

During the last few years, a disease of coconut palms hitherto not reported from this area has been observed. This is causing death of coconut plants in large numbers and is a cause of great anxiety to the growers. The initial symptom of the disease appears at the tips of the lower whorls of leaflets which become yellow at first and gradually turn brown. The yellowing proceeds from the tips to the laminae of the leaflets and gradually the entire frond becomes yellow. In affected plants, the lower whorls of leaflets were seen to first become yellow and the yellowing gradually progressed to the upper whorls of leaflets. By the time the leaflets situated on top were affected, the leaflets of lower whorls turned deep brown, midribs broke, shredding of leaflets occurred and the discoloured frond remained hung up like a twisted arm and eventually became detached from the stem. (Fig. 1). In severely diseased plants, longitudinal cracks appeared on

Figure 1. Coconut plants in a grove affected by the yellowing disease. Arrow indicates the site of a dead coconut plant.
stems. Often resinous exudates were soon coming out of the cracks attracting ants and other insects. The disease attacked and destroyed palms of all ages. Plants suffering from the disease and bearing fruits showed frequent fruit fall and subsequently all the fruits fell. The skin of the affected fruits showed loss of the usual greenish tinge, became dull yellow, appeared water-soaked and the outer tissues of the fruits became soft, shrank and became dark brown in colour. The affected fruits on cutting into two halves were found rotted from inside. Roots of affected plants of various ages were excavated and examined. The extent of rotting of roots was found to be proportionate to the discoloration of the diseased plants. Saplings and tender plants were found to be more susceptible to the yellowing disease and recovery from the attack was sometimes noticed. In severely affected plantations in which the age of the coconut plants ranged from 3 to 5 years, more than 50% of the plants succumbed to the attack of this disease. Depending on the age of the plants, it took 2 to 6 months for the plants to die from the time of the initial appearance of the disease symptom. McCoy (1976) has made a comparative study of the epidemiology of lethal yellowing, Kaincope and Cadang-Cadang disease of coconut palms. Maramorosch and Hunt (1981) has reviewed the lethal yellowing of coconut and other palms. In Tanzania lethal disease syndrome has been investigated by Schuiling et al. (1981) and further studies on the presence of mycoplasma like organisms in tissues of lethal diseased of coconut palms have been conducted by Deutsch and Nienhaus (1983). In India, association of mycoplasma like organisms with coconut root wilt disease has been reported by Solomon and Govindankutty (1983). McCoy (1975) obtained some success in controlling the lethal yellowing by the application of oxytetracycline.

<table>
<thead>
<tr>
<th>Microorganisms isolated from diseased parts of Coconut plants.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roots</strong></td>
</tr>
<tr>
<td>Rhizoctonia solani</td>
</tr>
<tr>
<td>Macrophomina phaseolina</td>
</tr>
<tr>
<td>Botryodiplodia theobromae</td>
</tr>
<tr>
<td>B. palmarum</td>
</tr>
<tr>
<td>Fusarium semitactum</td>
</tr>
<tr>
<td>Bacteria (Rods)</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

The cause of the coconut disease prevailing in Karachi is not known. Symptomatically the disease has a resemblance with the reported lethal yellowing disease of coconut palms (McCoy, 1976). Fungal and bacterial organisms were isolated from the affected parts of coconut plants (Table 1). The isolated organisms, on the basis of the frequency of their occurrence from the diseased leaves, fruits and roots could not be associated with the yellowing disease. Since it was not possible to make an ultramicroscopic study of the diseased tissues, an attempt was made to see the effect of the application of some of selected fungicide and pesticide. A 0.2% solution of Benlate, Captan and Melathion was prepared separately with tap water and 300 ml was applied to a diseased plant. Diseased coconut plants were treated with the solutions in different ways as shown in Table 2. The treatment was repeated at an interval of 7 days, for a month followed by an interval of 15 days for another month. The plants of the control series were selected at a distance of 30
m and were kept isolated from either foliar spray and soil disinfection. The treatment of diseased plants was carried out at three different places in Karachi with 40 plants at each receiving fungicides and pesticide in different applications (Table 2), and a similar series was left as control. A remission in the incidence of the disease in 3–5 year old coconut was noticed when Benlate and Malathion was used as foliar spray and as soil disinfectant. Whereas the causal organism for the yellowing disease of coconut palms in Karachi remains unknown, treatment of diseased plants at an early stage with benlate and melathion as foliar spray and soil disinfectant offers some hope in the remission of the disease.

REFERENCES


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When replying to this advertisement, please mention the Commonwealth Forestry Review.
SEED PRETREATMENT METHODS FOR Guazuma ulmifolia Lam

By Janet L. Stewart* and P.G. Gosling**

Introduction

Guazuma ulmifolia Lam. (Sterculiaceae) is a widely distributed and popular tree in Central and South America. It is found from Mexico to northern Argentina and in the Caribbean (Salazar and Quesada, 1987) at altitudes from sea level to 1000 m. Although widespread in both wet and dry areas it appears to prefer a seasonally dry climate with 600-1500 mm annual rainfall.

Guazuma is widely appreciated by farmers throughout its native range, as it possesses several valuable attributes. The sweet fruits are eaten in great quantities by horses and cattle; in Costa Rica, horses are reported to eat 800-2000 at a single meal (Janzen, 1983). The fruits are also edible for humans and can be made into a drink. In addition, the foliage provides good fodder for cattle, horses and goats; Guazuma is one of the few tree species used for forage in Central America. The wood is exceptionally good fuel (National Academy of Sciences 1980) and the tree can provide shade to livestock as it retains its leaves in all but the driest areas. Finally, its vigorous resprouting ability, after coppicing or pollarding, makes it suitable for use in live fences.

* Oxford Forestry Institute UK
** Forestry Commission UK.
Despite the clear potential of this species, it has until recently been little known outside its native range. It was included in a recent series of species trials coordinated by the Oxford Forestry Institute (Hughes, 1986) and preliminary results from these show *Guazuma* to be very successful on some sites, notably in low-altitude areas of Nepal. Another important finding, however, has been the very variable germination achieved in nurseries raising seedlings for the trials. When wetted, *Guazuma* seed develops a sticky gelatinous coating, which is thought to inhibit germination but which is very difficult to remove by rubbing or washing. It was decided to resolve the question of seed pretreatment by the full laboratory study described here.

**Methods**

The pretreatment study was carried out at the UK Forestry Commission Research Station, using seed collected in February 1982 at La Trinidad (Estelí), Nicaragua. Fourteen pretreatment methods were tested, using four replicates of 100 seeds in each case. After pretreatment, the seeds were set up for germination on top of filter paper set on a glass slat on a Copenhagen tank. The temperature was maintained alternately at 30° for 8 hours and 20° for 16 hours, with light during the 30° phase. Germination percentage was recorded at 7, 14, 21 and 28 days.

All the pretreatments consisted of variations and/or combinations of four basic methods:

(A) Seed soaked in 5 volumes of water at 20° for 18 hours.

(B) 5 volumes of boiling water poured over the seeds, left for 30 seconds then drained off.

(C) Dry seeds rubbed between 2 sheets of sandpaper (no. 70 grit).
(D) 5 volumes of water at 60° poured over the seeds and kept in an incubator at 40° for 3 hours.

For all the water treatments, the seeds were stirred with a glass rod to help separate them, then drained before being set up for germination. The treatments were combined as follows:

1. Control; no pretreatment.
2. (A).
3. (A) then (B).
4. (C) for 2 minutes.
5. (C) for 5 minutes.
6. (C) for 8 minutes.
7. (C) for 10 minutes.
8. (C) for 5 minutes, then (B); seeds then spread out on filter paper, under lights, at 30° for 8 hours, to simulate sun drying, before setting up for germination.
9. (D).
10. (C) for 5 minutes, then (A).
11. (A); seed then pressed through a fine metal sieve to help break up the gelatinous coating.
12. (C) then (B) then (A).
13. (B) then (A).
14. (B).

**Results**

<table>
<thead>
<tr>
<th>Method No.</th>
<th>Day 7</th>
<th>Day 14</th>
<th>Day 21</th>
<th>Day 28</th>
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<tbody>
<tr>
<td>1</td>
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<td>5</td>
<td>5</td>
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<td>3</td>
<td>16</td>
<td>72</td>
<td>85</td>
<td>87*</td>
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<tr>
<td>4</td>
<td>4</td>
<td>4</td>
<td>10</td>
<td>10</td>
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<td>26</td>
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<tr>
<td>14</td>
<td>27</td>
<td>67</td>
<td>84</td>
<td>87*</td>
</tr>
</tbody>
</table>

*Highest germination percentage.
Discussion

The simplest method of obtaining the highest germination was a short soak (30 seconds) in boiling water. Previous or subsequent soaking in cold water gave no extra germination. Treatment with cold water was entirely ineffective, and water at 60° also gave poor results.

Although the purpose of the gelatinous coating around the seed is not known, the theory that it inhibits germination may be supported by its appearance after different pretreatments. When untreated seed is set up for germination the jelly layer develops to its full extent over 24 hours, then takes several days to break down and disperse on the filter paper. After treatment with boiling water or rubbing, the jelly does not extend fully, and also disperses more quickly. It appears that weakening of the jelly layer is the key to successful germination. Under natural conditions this is achieved by passage through the digestive tract of animals (Janzen, 1982); the effectiveness of this is demonstrated by the spread of *Guazuma* along roadsides and fence lines in Central America.

Pretreatment with boiling water has the disadvantage that the seeds tend to clump together when wetted, making separation for sowing difficult. Despite this it is clearly shown by this study to be quicker, easier and more effective than the washing and physical scarification methods that have been used with such mixed results in the past.

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COMMEMORATIVE AWARD

The Commonwealth
Presented to Forestry Association

MICHAEL J. HALL
President, AFDI

ROSS PARNELL
Chairman, Conference Committee

Dated at Albury-Wodonga this 26th day of April, 1988
Forests and Foresters

Foresters see themselves — ourselves — as the guardians of the woodland and its environment and as the managers that optimise the goods and services which the resource can generate and sustain. There are many examples of tracts of land now reserved under trees which would have been lost had it not been for the foresight, dedication and perseverance of earlier rotations of foresters. Many new ‘man made’ forests have been created to provide a source of raw material, a habitat, environmental stability and a productive source of employment. The forester works within a cycle of cultivation, utilisation and regeneration.

However, the trees are being discovered by a new articulate generation who enthuse over some transitory stage in the forest’s life and in their attempts to perpetuate the unsustainable, destroy the fabric upon which future frescos might have featured. Some of our green politicians pay scant attention to the derived wisdom of the forestry profession and the latter’s training, education and experience is an anathema to the bright eyed amateur.

The early resident populations of North America carried out controlled burning to provide a scatter of site types and age classes of their trees. The policy of subsequent fire suppression led to a reduction in types of habitat and an increase in the collection of inflammable material. A more ‘enlightened’ policy of being prepared to let the fires from dry lightning strikes run their course has needed revision again in 1988 when the ‘natural’ fires in Yellowstone threatened to inflict irreparable damage to the habitat, burning some 360,000 ha of forest.

The felling of the tropical forest is now appreciated to be at a rate where the resource might well be lost within the next 30 years. Improved communications have shown that the 32,000 square miles of forest felled and burnt in Brazil during the last three months shows that clearing is taking place at a rate four times higher than earlier in this decade. Quite apart from the destruction of the habitat and the loss of the resource, the generation of carbon dioxide by this burning is assessed at 700 MT; some 10% of this year’s man made or man influenced production. The perceived justification for this clearing is that the growth of foodstuffs for consumption both home and abroad will serve political ends but the foresters will be able to demonstrate that the chances of sustained agriculture are sufficiently remote that this razing of the forest in an attempt to raise cattle is a short term expedient which, when it has failed, leaves a ravaged resource with drastically reduced options for future husbandry. The future of the tropical forest depends upon the foresters convincing the politicians — whom we hope are representatives of the community at large — that the forests and their produce can make the optimum long term contribution to the country and its inhabitants. Timber is just one of the forest’s products but all hues of political thought should wish to see this value enhanced otherwise the justification for the continuation of the forest is diminished.

In the past, the forester has been an isolated individual with his or her specific responsibilities, thinking in terms of rotations of 20 to 200 years. However, the success or otherwise of the foresters in Australia during the last few months of 1988 will have an impact right around the world. Unless these foresters are able to demonstrate that management of silvicultural reserve areas is within their remit and that the continuity of reserve status is compatible with commercial operations, less developed countries may follow the lead of their politicians and deny reserve areas of their commercial logging
values. This depreciation of the financial returns from the reserves will speed up their erosion by other interests and the loss of habitat and employment will follow the reduction in revenue.

Annual Meeting 1989

The venue for the 1989 AGM will be Dumfriesshire in Scotland. The dates are the 25 and 26 of May with the AGM, by kind invitation of our President, at noon at Drumlanrig Castle on the 25 May. The Secretary has a list of hotels and accommodation within six miles of Thornhill. This list will be sent to those who express an interest. Final details of the programme will be published in the December issue of the Review.

Fellowships

The Royal Society (established 1660), has placed 108 Fellows in British Universities during the last five years. Salary is at the same level as the lecturer. Post Doctoral candidates should be in the 26–33 year age group with a scientific background, prepared to work in scientific and engineering departments for a minimum of 5 years and a maximum of 10 years. It is hoped that further senior lecturing work will be undertaken.

The Royal Society and the Japan Society for the Promotion of Science scheme offers 10 fellowships a year. Six new post doctoral fellowships are now being offered by the Royal society for scientists, including those allied to forestry. Applicants sould be under 35. Periods of study, at any of some 100 national laboratories and public research corporations in Japan, may be from 6 to 24 months. These six posts are to be taken up before April 1989. Benefits include return air fare, living and housing allowances. Further details are available from Miss K. Kimpton, The Royal Society, 6 Carton Terrace, London SW1Y 5AG.

An annual prize of $10,000 is offered for the doctoral dissertation that makes the most significant contribution to the field of environmental and resource economics. Applicants would be nominated by their universities for the year 1988 and in due course for 1989 with the details being sent to Dr. John F. Ahearne, Resources for the Future, 1616 P Street N.W., Washington D.C., 20036 USA.

Canadian Fellowships for disciplines which include Agriculture and Environment are available for a period of one year. Applicants should have a PhD or have had two years work after obtaining their Master's degree. There are no citizenship restrictions other than that the Canadian Immigration requirements must be satisfied. Further details may be obtained from the Visiting Fellowship Officer, Natural Science and Engineering Research Council, 200 Kent Street, Ottawa, Ontario, Canada K1A 1H5.

The International Institute of Tropical Agriculture in Ibadan, Nigeria is offering post doctoral research for those whose subject is sustainable farming in sub-humid tropics. The salary will be in US dollars and fellowships ‘include the cost of transportation’. Details may be obtained from the I.I. of T.A., Oyo Road, PMB %fè, Ibadan, Nigeria.

Apologies

The Editor apologises to W. E. Hillis, Honorary Research Fellow at CSIRO, for errors and alterations to the text of his article ‘A Review of Forest Products Utilisation in Australia’ which appeared in Volume 67(1) of the Review. The following changes are pertinent:–

P. 76, line 25, the phrase ‘a grader’s strength denoting colour marking’ should be replaced with ‘the colour markings denoting its strength that have been made by such a grader’. 
P. 79, line 15 ‘Pacific Basin’ is to be replaced with ‘Pacific Region’ and the area of plantation should be 3.5 Mha, not 35Mha.
Line 28 should read ‘... wood-laminates from low quality and small-sized resources using more versatile, low cost adhesives and gluing procedures. ...
P. 80, line 21, the word ‘veneer’ should be replaced with ‘overlay and structural plywood’.

Initiatives to assist the continuation of the Tropical Rain Forests

The Timber Trades Federation obtained unanimous backing from representatives of the tropical timber importing and manufacturing trades to pursue the suggestion of making a surcharge on all forms of tropical timber imported by Britain. This is planned to raise an annual figure of US$30M which is to help the producing countries counteract forest loss. The Netherlands has adopted a similar policy. The subject will be discussed by the European Commission in November in liaison with the European timber traders and the International Tropical Timber Organisation. The latter is envisaged as the vehicle through which the funds might be channelled to improve the socio-economic and environmental role of the world’s productive rain forests.

The Rolex Awards for Enterprise

The next year for awards is 1990. Applications should be lodged to ‘The Secretariat, The Rolex Awards for Enterprise, PO Box 178, CH 1211 Geneva 26, Switzerland’.
In addition to the award of a gold Rolex Chronometer, there is a cash sum of 50,000 Swiss francs. There have been 20 awards, 5 at three year intervals. The award is intended to provide financial assistance to persons with the spirit of enterprise, in order to allow them to carry out unconventional projects in one of the following broad fields:—
Applied Science and Invention, Exploration and Discovery, The Environment.
Previous projects which members might have thought were within their own scope include those of:—

André Martin, who runs a forestry company in Provence. He developed a novel and effective method for protecting forests from fire and for recycling forest waste products.
Milan Mirkovic from Australia who planned that plantations of jojoba would produce such fine oil, comparable with that from the sperm-whale that the hunting of the species would cease to be put under such threat.
Donald Ray Perry produced scrambling nets to assist in the investigation of wild life in the canopy of the rain forests.
Pierre Morvan is a Parisian taxi driver who is preparing a major work on the ground beetles of Nepal.
Projects should be presented in English to the above ‘Secretariat’ by the end of March 1989. The awards will be announced in April, 1990.

June Meeting of the Association in Kuala Lumpur

An informal local meeting of the Association was held in connection with the IUFRO S4.01/4.02/1.07 Meeting “Growth and Yield in Tropical Mixed/Moist Forests” at the Holiday Inn City Centre, Kuala Lumpur on 22nd June 1988.
This was attended by four members and seven others, out of the 50 foresters attending the IUFRO meeting.
The aims of the meeting were:

1. to advertise the activities of the Association, especially the Queen's Award for Forestry and the importance of the Review for publication of papers on the research and management of tropical forests and their utilization.
2. to invite comments and suggestions from members who may have little opportunity of attending meetings which are mainly confined to the U.K. or the locations of the Commonwealth Forestry Conferences.
3. to encourage further membership.

Points discussed included: the value of the Review; how local branches of the Association could be built up to serve the needs of the Association better; the need for more efforts to enrol members. Dr Rai, the Local Secretary for India, asked that he be supplied with a bulk supply of application for membership forms and other publicity material. All Local Secretaries could be asked to take similar action.

The inconvenience and cost of paying by international money order was seen as a serious disincentive for overseas prospective members. It was proposed that alternative forms of payment should be investigated by the Executive Council, such as the use of credit cards (too expensive for the Association?), or arrangements with local banks with offices in the U.K. to accept local currency, or ask Local Secretaries to be responsible for collecting subscriptions (in this case they should be refunded any costs involved in sending a single annual transfer).

The Association was seen as a link with the Oxford Forestry Institute and the library services. Dr Primack found the cost of material requested in the past excessive (up to $1 a page). PGA agreed to pass on the comment to the Librarian.

Application forms were taken up at the IUFRO meeting and seven people expressed an interest in joining.

Diploma in Timber Studies, Buckinghamshire College

The one year Diploma in Timber Studies course at the Buckinghamshire College of Higher Education aims to train graduates or experienced management and technical personnel in wood technology, but it also prepares the students for their role in industrial management. Some 160 students from over 50 countries have qualified during the past 14 years the course has been offered.

This year eleven students were awarded the Diploma in Timber Studies and also the Management Studies Certificate. The specialisation subjects of those awarded a Diploma are as follows:

<table>
<thead>
<tr>
<th>UTILISATION:</th>
<th>Clayton Hall (Guyana)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>1st Class Honours.</td>
</tr>
<tr>
<td>Martin Majak (Sudan)</td>
<td></td>
</tr>
<tr>
<td>Ruschai Rhienpanish (Thailand)</td>
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<td>Roger Summer (U.K.)</td>
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<th>DRYING:</th>
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<td>Edmund Zwizwai (Zimbabwe)</td>
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| SAWMILLING:           | Beryl Haroan (Indonesia) |
|-----------------------| Eamonn Oliver (Zimbabwe) |
|                       | Rodney Thomas (St. Helena) |

| WOOD-BASED PANELS:    | Alan Robertson (Zimbabwe) |
EDITORIAL

FURNITURE PRODUCTION: Daniel Nmary (Tanzania)

This year's winner of the Price and Pierce Prize of £100 was Clayton Hall.

The class of 1988 with some of their tutors.

The Joint FAO/ECE/ILO Committee on Forest Working Techniques and Training of Forest Workers

The Joint committee was created in 1954 as a forum for the exchange of information and experience among the countries of Europe and North America on forest working techniques and the training of forest workers. It is a main subsidiary body of the European Forestry Commission of the United Nations Food and Agriculture Organization (FAO) and of the Timber Committee of the United Nations Economic Commission for Europe (ECE); the International Labour Organisation (ILO) is also a sponsoring agency.

The task assigned of the Joint Committee is to foster international collaboration on technical, economic and organizational aspects of forest working techniques and training of forest workers in logging and other forest operations. Special attention is given to the development and implementation of forest-use planning and general management; increasing the efficiency of labour; the reduction of the physical efforts of forest workers; the prevention of accidents; the reduction of waste; and the establishment of an adequate balance between the technical, social and economic requirements and protection of the environment.

Many aspects of the Joint Committee's work are of interest not only to national forest services and other government officials directly concerned with forestry but also to specialists throughout the forestry and forest products sector.
The Joint Committee’s programme of work has been drawn up primarily with the problems and priorities of its thirty-four member countries in Europe and North America in view. Much of its work is nevertheless applicable to countries in other regions. The Joint Committee accordingly welcomes participation in its activities by experts from countries in other parts of the world and looks for ways of facilitating the transfer of the know-how it generates to all those who may benefit from it.

The Joint Committee collaborates closely with a number of international governmental and non-governmental organizations working in the same field, notably the International Union of Forestry Research Organizations (IUFRO), the International Organization for Standardization (ISO) and the International Energy Agency (IEA).

The majority of the Joint Committee’s projects are carried out by the organization of seminars or by teams of specialists. Wherever possible, projects are completed within a given period, usually varying between two and four years, and are then replaced by others chosen by the Joint Committee from the proposals it receives from member countries, its parent bodies, its own seminars, etc. Meetings are organized jointly with IUFRO, whenever possible.

Special meetings

During the past decade, seminars or symposia have been held on many different topics. In a Special Issue of the Timber Bulletin (Volume XXXIX, No. 3) entitled ‘The development of forest working techniques and the role played by the Joint FAO/ECE/ILO Committee on Forest Working Techniques and Training of Forest Workers’ all relevant information about special Joint Committee meetings up to and including 1986 can be found, i.e. lists of courses, symposia and seminars held and publications issued.

The following seminars are in preparation:

1989  Seminar on the protection of soils during forest operations (Belgium) (subject to confirmation)
      Seminar on the mechanization of harvesting operations in mountainous terrain (Turkey, November)
      Seminar on vocational training problems in forest operations (Finland)

1990  Seminar on safe techniques of chemical application in forestry (United Kingdom) (subject to confirmation)
      Seminar on seed collection and storage (country to be decided)
      Seminar on wood energy/residues (subject to confirmation; country to be decided)

1991  Seminar on forest fire prevention (subject to confirmation; country to be decided)
      Seminar on multi-functional machines in logging operations (subject to confirmation; country to be decided)
      Seminar on ergonomic problems in forestry (subject to confirmation; country to be decided)

If you need information on seminars, documentation or other features of the Joint
Committee’s activities, please write to: The Timber Section, ECE/FAO Agriculture and Timber Division, Palais des Nations, CH-1211 Geneva 10, Switzerland.

Papers and publications/Seminar proceedings

Basic papers presented to seminars are issued in a limited number of copies. These papers (as well as voluntary ones which are distributed by their authors to seminar participants) are subsequently published, whenever possible, in the form of proceedings by the countries that had hosted the seminars, and are normally available free of charge.

List of publications/proceedings and papers still available

A limited number of reports of some proceedings are still available from the Timber Section in Geneva or from the address given with the report title:

- List of organizations engaged in forest working techniques, mechanization and/or environmental problems related to forestry (TIM/EFC/WP.1/6, English, French and Russian, 1977).
- Maintenance of forest machinery in large- and small-scale forest operations (Sweden, 1981).
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CORRESPONDENCE

Department of Forestry,
Australian National University,
GPO Box 4,
Canberra Act 2601

23 June 1988

Dear Sir,

In an article CFR 67(1) 1988 pp. 53-64, J K Vanclay and N B Henry discuss the use of “site form, the expected height of a 25 cm d.b.h.o.b. tree predicted from the stand height — diameter relationship (as) a practical and useful measure of site productivity” in uneven-aged stands of indigenous cypress pine in southern Queensland.

I appreciate the authors problem in finding an especially suitable name for an index to site productivity in such stands; nevertheless, I suggest the choice of “site form” is unfortunate and its further use is to be deprecated.

“Form” in forestry terminology has long-standing connotations of “shape”, as it has in general usage, and it would seem sensible not to use it in circumstances where, as here, there are no such connotations unless there are particularly persuasive grounds for doing so. I certainly fail to see any and the senior author does not appear to provide them in the previous work to which reference was made.

It would be a pity if, by its promotion in a special Australian bicentenary edition of the Review, the term would appear to your readers to have general recognition by mensurationists in this country. I am confident this is not the case.

Yours sincerely

L. T. CARRON

Sabah Forest Industries Sdn Bhd,
WDT No.31
89859 Sipitang
Sabah
Malaysia

19 July 1988

Dear Sir,

We write to correct some inaccuracies that appeared in the March 1988 issue Vol. 67(1), No.210 of The Commonwealth Forestry Review on your article on Malaysia under the section “Around the World”.

The following statement on Sabah Forest Industries SDN BHD plantation should provide figures to replace the exaggerated figures quoted in the March 1988 issue of the Review.

SFI is a private limited company wholly owned by State Government of Sabah set up in July 1984 to implement the country’s first integrated pulp and paper project. The mill is located about 160 km south of Kota Kinabalu and 38 km to the Sarawak border.

The main activity is to manufacture quality printing and writing paper from mixed tropical hardwood and plantation wood with a small supplement of long fibre pulp. The
mill has a rated capacity to produce 125,000 tons of paper per year, utilising some 910,000 m³ of mixed tropical hardwood. The mill construction was mechanically completed in February 1987.

The mill’s raw material will initially be residues wood from the 300, 332 ha of forest concession area located in Sipitang, Sabah. Future raw material for pulping will be from fast growing hardwood plantation established in the nearby forest areas within economic distance from the mill.

In the initial years, the mill’s wood requirement will be met by clearfelling the relatively flat area (under 25 degrees) of the logged-over forest. These clearfelled areas are to be replanted with fast-growing species. The plantation thus established will, upon maturity in 8 years, provide a perpetual pulpwood supply to the mill. The rate at which this plantation is established will be synchronised with the rate of clearfelling the residual forest estimated to be 3,415 ha/year. We will reach a state of equilibrium where it will be possible to manage the large area of our native forests (some 240,000 ha) with only light loggings for producing high value sawlog on a sustained yield basis; while the relatively small areas of plantations (58,000 ha) will meet the entire millwood requirement, assuming plantation cycle of 8 years, and a mean annual increment of 20m³/ha/year.

The species choice for the planting program are based on hardy fast growing species with good paper making properties and also suitable for general purpose timber. Out of the many species which have been and are continuing to be tested, the main fast growing tropical hardwood species that has already been planted by SFI are *Acacia mangium* and *Gmelina arborea*. Other potential species which are showing promising performance in our test plots are *Acacia crassicarpa*, *Acacia aulacocarpa*, *Acacia auriculiformis*, *Eucalyptus camaldulensis* and few other Eucalypts.

To date, the company has planted some 4000 ha of commercial plantation.

As part of our effort to integrate the local communities into the project, a program of private tree farms has been introduced. Under the scheme, private landowners may qualify for subsidised planting material and free technical advice to plant their idle land and secure a guaranteed purchase of the wood upon maturity.

Tree farming has been introduced to the idle land around the project area as a strategy to raise rural income and provide the mill with a supplementary source of wood in the future.

The tree farm project was started with financial support provided by a pilot scheme under the Sabah World Bank Technical Forestry Assistance Project. To date, over 700 ha have been planted involving 282 land owners. More are expected to be planted within a 60 km radius of the mill. There is good probability that 10,000 ha private small-holdings now available would be eventually planted.

Yours sincerely

for
SABAH FOREST INDUSTRIES SDN BHD
RUDY TANGIT KINAJIL
(General Manager (Forestry and Timber))
Dear Mr President/Editor-in-chief,

According to the Science Report broadcast by the Voice of America on July 8, 1988, the world forest coverage has been reduced 30% within a not long period of time. The rate of decrease of forest coverage is alarming. No intelligent person might remain unmoved with the information. Free flow of information and idea is indispensable for the civilized world. We expect to receive a letter from you about how you consider the problem of world deforestation. We’d like to know your approach toward this problem which concerns not only the climate pattern but also the very environment of this planet. May we share some imagination and initiative, for instance, following the example of the World Watch Institute, a private organization in U.S.A. that released the report about world forest decrease broadcast by VOA. We might establish a World Forest Resources Watch Group or World Forest Watch Group. While there is the Oscar Reward to best films, we might start a kind of Prize, say ‘Global Canopy Reporting Prize’ to the most distinguished newspapers, magazines, T.V. and radio systems, journals and other media institutions for their reports on forest preservation every three years as recommended by Forestry Associations and Societies of various countries. Medals of bronze, although not high cost, will symbolize the appreciation of readers and audience. Your opinion and suggestion in your letter to us will be published in brief in our journals.

By the way, some readers suggest that we should write to you about the serious threat of population explosion to world forest resources. They suggest that a symposium of world media should be held as soon as possible anywhere in the world. The aim of the meeting is to discuss what the world media community might do in concerted effort to preserve the forest resources of the planet. The meeting might accomplish something very important. First, to further attract the attention of the world public to the danger of destruction of forests with satellite transmitted TV show. Second, to discuss concrete methods to jointly monitor the situation and to plan periodical and systemic examination on site in the future.

Media should be whistle-blowers to protect the already very much limited forests on this planet.

We would be glad to know whether you consider it feasible to convene a symposium, named ‘World Media to Accept the Challenge of Saving the Forests of the Planet’. The first meeting might be convened somewhere in some country, say in China, in the spring of 1989. After and before the meeting we might make several study tours to some endangered picturesque and vitally important forests such as the tropical rain forests in Hsishuang Panna in Yunnan Province, the natural forests in Changbai Mountains in the northeast part of China and the forests where pandas choose as their habitat. As noted by the VOA July 21 Breakfast show, the world community is concerned about the possibility that the panda will entirely disappear from the earth with the disappearance of the rapidly decreasing small region of forest where they live now.
Your response and suggestion will be appreciated.

Best wishes

Sincerely yours

Mrs Zhang Zhongchen

Executive Vice Editor-in-chief
Editorial Board of the Journal
‘Forests and Man’

Mr Wei Baolin

Editor-in-chief
Editorial Board of the Journal
‘World Forestry Research’

Mr Xu Guanhua

Director and Professor
Research Institute of Forest
Resource Information,
Chinese Academy of Forestry

Dear Mr Baolin

Thank you for your letter of 9 August. As President of the Commonwealth Forestry Association I can assure you that we wholeheartedly endorse your concern about the various threats to the world’s forests.

We are ourselves having a Forestry Conference for British Commonwealth countries in Rotorua, New Zealand in September next year at which, amongst other things, we shall spend a whole day discussing initiatives for the Tropical Forestry Action Plan. The theme of the Conference is ‘Forestry — A Multiple use Enterprise’ and one of the subsidiary themes is ‘Innovation’ — which will include suggestions for Soil and Water Management, Tree Improvement, and Disease and Pest Control, which are essential pre-requisites for healthy forests.

Although this is primarily a Commonwealth Conference it is open to citizens of other countries to attend and it could form a useful follow-up, at least for technical forestry staff, to your own proposed conference which I imagine is directed towards a wider audience. I enclose some details of our conference and we would be delighted to mentioned your own conference in our Quarterly Journal The Commonwealth Forestry Review when the details have been finalised.

In your letter you mention the idea of study tours of some of your forests in Yunnan Province and in Changbai Mountains and I must say this is something I would very much like to do. However, as I am confined to a wheelchair, which can make accommodation difficult, this may never be possible. I sometimes wonder whether the sycamore seedling I handed over when visiting Beijing in 1985 as guest of Mr Deng Pufang and his China Welfare Fund for the Handicapped is surviving.

Yours sincerely

The Duke of Buccleuch KT
President, Commonwealth Forestry Association
Dear Sir,

IUFRO PROJECT GROUP P 1.15-00 AGROFORESTRY

Call for membership

Since the establishment of this Project Group at the 18th IUFRO World Congress in Ljubljana in September 1986, several persons have declared an interest in joining the Group. However, so far, no systematic exploration of potential interest in membership in the Group has been made. Through this announcement we invite you to write to the relevant office holder listed below to declare your interest to become a member. We would also appreciate ideas and proposals on possible activities for the Project Group.

All researchers with an active interest in any aspect of agroforestry who are staff members of a forestry research organization that is affiliated with IUFRO can become members. It should be emphasized that the Project Group will mainly work on questions which are directly related to the forestry profession's input into the multidisciplinary discipline of agroforestry, e.g. establishment, management and improvement of multipurpose trees on farms and in pasture; and the utilization and economics of such trees for fuel, fodder, poles and processed products. Furthermore, the Group ought to address the institutional question of how the forestry discipline can best integrate its efforts with other disciplines — agriculture, social and economic sciences, etc. — to achieve relevant and efficient research agenda for developing agroforestry technologies and systems.

Following your reply to this call, a tentative membership list will be circulated and proposed activities of the Group up to the time of the 19th IUFRO World Congress in Montreal in August 1990 will be communicated.

Yours truly
Dr. Bjorn Lundgren
Chairman and overall Co-ordinator
Responsible for membership and activities in Africa and Europe

Co-Chairman
Responsible for membership and activities in Asia and the Pacific

Co-Chairman
Responsible for membership and activities in South, Central and North America

Prof. P. K. Khosla
College of Forestry
Dr. Y. S. Parmar
University of Horticulture Forestry
Solan 173 230
INDIA

Prof. G. Budowski
Head — Programme of Natural Resources and Quality of Life
University of Peace
San Jose,
COSTA RICA
Dear Mr Rogers

INTERNATIONAL INVESTMENT IN FORESTS

Enclosed is a copy of the letter I sent to the FAO and the World Bank regarding the International Investment in Forests.

It is a plea to select out those large international projects which are best placed to meet the world’s future needs. These would then be advertised for the mutual benefit of the country itself and international resource developers who would fund the proposals in the end. Too often the current resource expansions are not in the most appropriate places due to biological, political, social or economic constraints to meet the international needs for commercial wood.

In other words, it is a plea for a focus on the World rather than sub-optimal resolutions on a country by country basis and with development funded by industry rather than by Governments. To change that emphasis, the world organisations need to collect and analyse data on which the world’s entrepreneurs can act.

Mike Malloy’s* suggestion for the creation of a World Forestry Perspective giving rise to a Global Forest Data Base arose when initiatives were requested at a recent International Forestry Conference at Albury, New South Wales, Australia in April 1988. The Conference was arranged to celebrate Australia’s Bicentenary and in particular to study the use of Australian species in subtropical, arid and temperate regions of the world. Over 30 countries were represented. It proved to be a successful ‘stocktake’ of the current state of the art in growing Eucalyptus, Casuarina and Acacia sp.

One paper produced a strong reaction from conference. John Campbell highlighted the rate of destruction of forests worldwide, and the rate of increase of the human population. Current trends in the population densities of trees and humans point to a world famine in the first half of the 21st century. Conference reacted by approving a direct approach to Governments urging them to take direct steps to stop forest mining.

Malloy feels that appeals to Governments to reverse the ‘mining’ of their natural forests or over-zealously preserving rather than managing them on a sustainable basis is rather useless. Governments take too short-a-term view.

Within purely national contexts, conservationist pressures had so far proved unable to resist commercial and fuelwood pressures in Africa, Asia and South America. He felt that the odd word of advice from a tiny group of foresters would not affect the outcome of the conflict.

Australia has already seen the impact of two centuries of forest exploitation. Our native forests have long been a source of durable, strong hardwoods. We have used them for general purpose construction, wharves, poles, posts, flooring, bridge timbers, sleepers and finishing timbers. So have other countries, such as New Zealand. For many of these categories the supply has diminished and prices have risen. Some materials have completely dried up. Others have been priced out of overseas markets. In this country we have seen the effects of uncontrolled mining which the world will experience as

*M.D. MALLOY, Solicitor and Forester, Auckland, New Zealand.
tropical hardwoods slowly disappear. New Zealand has felt the impact of Australia’s primary forest loss. As the preferred hardwood supply has dried up, New Zealand has been forced to shift to alternate materials, usually more expensive and derived from nonrenewable resources, such as poles made from concrete and steel. From a commercial perspective as the tropical rain forests are cut out, Malloy sees the future world scene as akin to the history of Australian hardwoods writ large.

Malloy suggests that, as this trend becomes more and more visible, the motivation of overseas importers of hardwoods to invest in temperate hardwood plantations will increase. Some companies have already signalled this kind of interest. As it increases, Malloy suggests that political and legal conditions in potential growing countries will become increasingly important to investors. So will their ability to influence Government policy through their power to direct large investment dollars to different countries. At present, would-be investors have not begun to consider their potential influence on policies relevant to long-term forestry investment.

In other words, our current international forestry choices are sub-optimal because the investment climates in a number of possible growing countries are sub-optimal. Projects are considered within nations rather than on a global basis. Malloy is saying that well-founded investment forestry cannot get under way until we design and build appropriate foundations from well prepared information on world wood requirements and on supportive growing conditions, physical, social, legal and political.

Proposal

Quotation

‘The annual increment of these plantations may be ten times that of natural forests. This could lead to diversification of world wood supplies involving countries like New Zealand, Chile, Brazil and South Africa which have invested heavily in plantations in the last few decades. However, it is still questionable whether these plantations will be able to provide wood of sufficient quality and quantity to satisfy the needs of the world market and whether the investment will be available in some politically high risk areas . . . . Time is not on our side. Industrial countries can no longer take the supplies of timber from world’s natural forests for granted and developing countries can no longer regard their forests as a source of unlimited wealth tapped at will to meet short-term cash needs . . . . I want to see more tree planting across the world and I want to see forest management and not forest exploitation.’ Campbell, 1988.

Background

International investment in forests has its problems. Comparatively few areas of the world have the physical capacity to expand plantation forests. Those that do, have varying human resources in terms of technical skills, scientific know-how, availability of labour, appropriate organisation and management. Overweighing these issues, however, is the problem of Government attitudes.

Commonly, Government perspectives are short-term. Plantation forestry demands long-term perspectives. Unaided, the two will not mesh. Forestry may need Government understanding and support in terms of non-punitive tax regimes and scientific research. If, however, people in Government have no direct knowledge of forestry issues and no sympathy for the time scales essential to forest planning, the existence of appropriate physical and human resources will not lead to forest establishment.

A practical method for world forest expansion is the creation of a tool of influence provided through International investment which can create a powerful mechanism.
Instead of being exploitive, it is proposed that the investment is guided to where success is best assured. Most states welcome overseas investment in industry. If that investment is sufficiently large, the decision of investors will become important to Governments. Scale is the critical factor. A number of large potential investors acting in concert, could well play a major role in setting Government policy on forestry.

Achieving concerted action on the part of the investors can only be attained through international collaboration. The task is akin to that of maritime certification societies. They set out to define safety standards for ships, check specific ships, and issue grading certificates for those ships based on compliance with the criteria. An international organisation could do the same thing in relation to the geophysical and human resources of given countries and to the legislation, stability and attitudes of their Governments.

Financial support for such an organisation should not be difficult. Potential investors could achieve significant economies by making use of the organisation’s knowledge and rating of target investment should welcome an organisation specifically set up to bring that about. Consumer and producer interest in a successful outcome to the organisation’s work would provide powerful reinforcement for financial support.

Assumptions

When we consider setting up any king of organisation, assumptions about the future are important for the decision-making process but are not always stated. For the record, three critical assumptions are made in suggesting the goals and functions of an international organisation. They are:

(1) Over the next half-century, the world will become increasingly conscious of the need to produce its solid fabricating materials from renewable resources (e.g. wood from trees), rather than from non-renewable resources (e.g. steel from iron ore, concrete, plastics from oil, etc.)

(2) The real price of energy will tend to rise over the next half-century, thus rendering the capacity of trees to convert costless solar energy into solid matter of increasing commercial importance.

(3) In commercial terms, the main problem area for tree-based products is likely to be solid wood for uses such as construction, engineering, marine piles and finishing timbers.

These assumptions can be subjected to some kind of empirical testing and evaluation.

Goals

If an international organisation is in contemplation, its major goals should be made explicit. The suggested goals are:

(1) To establish man-made forests in partial substitution for the destruction of forests in the northern hemisphere and in the tropical rain forest belt.

(2) To provide expert advice on the nature and placement of man-made forests on the basis of empirical evidence of predictable future demand for solid woods and of site suitability.

Functions

To attain its suggested goals, an international organisation would have to carry out a variety of tasks. The suggested list is as follows:

(1) To foster and support research into predictable world demand for solid wood.
(2) To collate and store information on the capacity of states to grow trees for specific end uses.

(3) To rate potential growing countries in terms of relevant investment criteria — e.g. political stability, crop security, population density and trends, legal mechanisms, and availability of forest land and labour for planting, silviculture, felling, logging, transport and processing.

(4) To rate potential growing countries in terms of scientific knowledge, availability of professional forest managers, and research capacity.

(5) To rate potential growing countries in terms of predictable tax regimes and population attitudes to forestry.

(6) To co-ordinate and support forest-related research.

(7) To co-ordinate and support research into expanding tree-based material usage (e.g. liquid fuels, plastics, construction materials, etc.)

(8) To act as an international information store for potential investors and land owners.

(9) To act as an advisor to Governments on world forestry issues.

(10) To ensure that the organisation deals only with technical matters objectively, avoids all ideological differences and treats all proposals and countries even-handedly.

**Method**

It is premature to discuss methodological and organisational detail for the suggested organisation which could easily be part of the existing Food and Agricultural Organisation, based in Rome or the World Development Bank, based in Washington. Nevertheless, a few broad principles might be recorded.

Foresters, in general, are unsophisticated in commercial matters. The proposed organisation will develop something of great value — commercially significant information which can be sold. The organisation is thus, potentially, self-supporting. To attain this position, the following principles seem relevant:

(a) Knowledge precedes, and delineates a path for investment capital — not vice versa. (Boulding, 1971).

(b) Money talks, but only large amounts interest Governments. Beyond a certain minimum, the magnitude of potential investment from overseas and the extent of influence are positively correlated.

(c) Money must remain subservient to the broad afforestation goals of the proposed organisation, and therefore be treated as a significant servo-mechanism or feedback medium.

(d) The biological model of human adaptation should always be preferred to economic conventions for public relations and operational procedures.

(e) The proposed organisation should be staffed in a lean and hungry manner, and therefore develop a habit of using ad hoc professional research, support and advisory services as required.

**Action**

It is proposed to put this statement to the Food and Agricultural Organisation, Rome and the World Development Bank, Washington for comment as one Conference’s
concern for the state of forest management in a global context and the need for long term perspectives that Governments tend to lack.

This is an appeal to F.A.O. and the World Bank which funds many of the forestry resource expansions in developing countries, to select out those large international projects which are best placed to meet the world’s future needs. These would then be advertised for the mutual benefit of the country itself and international resource developers who would fund the proposals in the end. Too often the current resource expansions are not in the most appropriate places due to biological, political, social or economic constraints to meet the international needs for commercial wood. This is particularly so as the world changes course in requiring materials from renewable resources rather than mined sources.

References


I felt sure that your members would wish to know that this initiative has been stimulated by our conference.

Yours sincerely

Michael Hall
National President A.F.D.I.

The Australian Forest Development Institute is The National Private Tree Growers Organisation and is incorporated in NSW as a Company not required to show Ltd after its name.
NEWS OF MEMBERS AND FRIENDS

J.C.K. Amuzu, who obtained his Diploma in Timber Studies from the Buckingham College of Technology, is now based at The Forest Utilisation Office, PO Box 209, Takoradi, Ghana.

Glen Blouin is the incoming Executive Director of the Canadian Forestry Association. The Association is a federation of Provincial Forestry Associations promoting public awareness, understanding and co-operation in the wise use and sustainable development of Canada’s forests and related resources of land, water and wildlife.

Christopher Carden is now in the UK at 39, St. Cuthbert Street, Wells, Somerset, after completing an assignment in Zaire.

Frank Coppock enjoyed his London visit, based as a CFA member at the Royal Commonwealth Society; he has returned to The Anglican Church Office, PO Box 19, Dogura Alotan, M.B.P., P.N.G., or rather, that is the address of his mail.

Fred Courtier, recently retired as Head Forester, Wildlife, in the East of England. At the Royal Show in July, the wife of the Forestry Commission’s Director General, Mrs. Audrey Francis, presented Mr Courtier with the Balfour-Browne Deer Trophy — for outstanding services to deer.

Julian Evans has returned to the British Forestry Commission as Principal Silviculturist (S) in research after two years on special leave as Director of the Environment and Development (IIED). In July 1988 he was awarded the degree of D.Sc. by the University of Wales for work which included longterm productivity research in Swaziland, silviculture of broadleaved trees in Britain, and two of his books ‘Plantation Forestry in the Tropics’ (OUP) and ‘Silviculture of Broadleaved Woodland’ (HMSO).

Peter Fowler, Professor of Archaeology at Newcastle University, has been appointed as the first Archaeological Consultant for the UK Forestry Commission.

J.A. Haines enjoyed carrying out the research for the undergraduate thesis. The title is ‘A longitudinal study of ecological awareness, attitudes and knowledge between BScF and BScFE students from First Year to completion of the degree at the University of New Brunswick.’

Peter Holden has been appointed Managing Director of Thames Board Ltd. This follows Igesund’s acquisition of the company from Unilever. The plant at Workington represents a £100 M investment for the production of cartonboard has its sawmill integrated into the operation.

J. Lepele has been appointed the Director of Conservation and Forestry for Lesotho following the retirement of Mr. Masila. Mr. Lepele is a qualified soil scientist. His previous posts in government included, Manager of the National Abattoir, Director of Field Services of the Ministry of Agriculture, Deputy Chief Conservation Officer and First Permanent Secretary of the Minister of Labour.

Peter McCarter is wished well for his appointment in the Forest Department of Moi University, PO Box 3900, Eldoret, Kenya.

Ian Napier has completed a tour of four years in Nepal. His address is 38, Milton Avenue, Bath where he is spending a year at the University on post graduate work.

Barlo Ramroop, financial controller of Tanteak (Trinidad and Tobago Forest Products Co. Ltd., announced a S2 M export order for 400,000 board foot of teak over the next
two years to the United States. The timber will be used in the furniture and boat building industries.

*Dennis Richardson* has retraced his steps of his 1963 tour of China and spent three months at the East West Centre in Honolulu. His article in this issue of the journal is one of the fruits of his 1988 visit to Tibet on behalf of the World Food Programme.

*Philip Shedley*, is offered the best wishes from the Association, in particular from West Australia; we hope his new hip joint serves him well.

*Gustav Steneker*, of the Canadian Forest Service, in his capacity as Executive Director of the International Union of Societies of Foresters, is planning for the 5th IUSF Congress to take place alongside the 13th Commonwealth Forestry Conference during September 1989 in Rotorua, New Zealand.

*Jim Sutton* is congratulated upon his award of MBE. He is Head of Purchasing for Shotton Paper Company plc. He has been purchasing 450,000 T a year of pulpwood and sawmill chips. The company’s current investment programme with its second newsprint machine will increase output to an annual 400,000 T which will increase the pulpwood requirement to 750,000 T a year.

*Kevin Wilkinsen*, after his work in Honduras, has the designation as Operations Support Officer for the Mid-Scotland Conservancy of the Forestry Commission. He is based at Portcullis House, India St., Glasgow, G2 4PL.
OBITUARY

Dr. Evan Richard Charles Reynolds, 1932–1987

Evan Reynolds was born in Wallington, Surrey and educated at the Purley County Grammar School. In 1950 he entered Imperial College (London University) from which he graduated with a B.Sc. in Botany in 1953 and a Ph.D. in Ecology in 1956. In 1959, after a short spell at the Forestry Commission Research Station, Alice Holt, he was appointed Senior Research Officer at the University Department of Forestry to collaborate in a government sponsored research project concerned with the influence of forests on water supply. He co-authored several research papers in this field. In 1977 he was appointed University Lecturer with responsibilities for teaching Forest Ecology, Plant Geography and Remote Sensing. He extended his research to the development and morphology of tree root systems, a field in which he gained increasing international recognition.

Evan was elected a Fellow of Worcester College in 1987, a fitting recognition of his achievements and integrity of life. He spent much of that last year at Dehra Dun in India lecturing and writing. An enduring memorial to him as a follower of Christ is the orphanage there in which he took a special interest. We extend our condolences to Joan and their three children.

L.L.
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WATSON, P.A., c/o Forest Industries Development Company Ltd., PO Box 631, Twickenham Park, Spanish Town, St. Catherine, Jamaica
FORTHCOMING INTERNATIONAL DATES


7/12/88 USA, Washington D.C. Annual meeting IS Tropical Foresters. Ref: W. T. Doolittle, 5400 Grosvenor Lane, Bethesda, MD 20814 USA.

28/11/88–3/12/88 THAILAND, Pattaya. Clonal, Genetic Seedling Forestry, IUFRO S2.02-08/9 S2.04-01/2. Preceeded by fuelwood week; post conference tours. Ref: George Gibson, ESNACIFOR, Apartado No. 2, Siguatepeque, Honduras. Telex 1234 PRODROME HO.


25/5/89–26/5/89 SCOTLAND, Dumfriesshire. Commonwealth Forestry AGM and Excursion. Ref: The Secretary, CFA, OFI, South Parks Rd., Oxford, OX1 3RB.


27/6/89–1/7/89 MALAYSIA, Kuala Lumpur, Woodwork 89 (Forestry, Timber Processing, Woodworking Exhib.) Ref: Randle Theobald, O.E.S. Ltd. 11 Manchester Square, London W1M 5AB, UK.

10/7/89–14/7/89 TRINIDAD AND TOBAGO, Port of Spain. International Conference: Leucaena in Agricultural Development. Ref: G. Garcia, c/o Dept. of Crop Science, University of the West Indies, St Augustine, Republic of Trinidad and Tobago, West Indies.
23. 7.89–26/7.89 USA, Boston. "Meeting Global Wildland Fire Challenges" (Joint USA/Canada Fire Services).
   Ref: G. O. Tokle, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269, USA

   Ref: G. B. Walford, Forest Research Bag, Rotorua, NZ.


   Ref: Professor Dr. H. Zöhl Albert Ludwigs Universität Institute, Bertoldstrasse 17 D-7800 Freiburg.


   Ref: Dr. Klaus Johann, Forstliche Bunderversuchsanstalt, Vienna, Austria.

   Ref: Ampfield House, Romsey, Hants SO51 9PA (Not 1988!).

   Ref: H. F. Kaiser, USDA Forest Service, PO Box 96090, Washington D.C. 20090–6090, USA.

   Ref: Jennifer Pok, Singapore E.S. Pte., 11 Dhoby Ghaut 15–09 Cathay Building, Singapore 0922.

   Ref: Deutsche Landwirtschafts-Gesellschaft, Zimmerweg 16, 6000 Frankfurt am Main 1. F.G.R.

   Ref: Profile Publishing, Auckland, New Zealand.

   Ref: Nathalie Geraud, French Trade Exhib. 197 Knightsbridge House, Knightsbridge, London SW7 1RB.

3. 7.90–8.7.90 GERMANY, Munich, INTERFORST'90 Trade Fair.
   Ref: Munchener Messe-und Ausstellungsgesellschaft mbH, Messegelände, Postfach 1210 09 D-8000 München 12.

6. 8.90–10.8.90 CANADA, Montreal. The 19th IUFRO World Congress.
   Ref: Contact Subject Group Leaders.
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AROUND THE WORLD

BRAZIL

Pulp and paper is now the most important Brazilian forest product for export, representing more than fifty per cent of the 1987's total revenue.

Natural forests in Brazil cover more than 350 million hectares, but most pulp and paper production depends on 6 million hectares of reforested areas established in the south and southeast regions. This area includes 4 million hectares of _Eucalyptus_ sp., that is the main raw material for pulp, paper and charcoal for steel production. Due to the increasing internal economic crisis, and pressures from international financial institutions, the Brazilian government has recently cancelled the programme of tax incentives for reforestation in the south and southeast regions. That decision, say leaders of the Brazilian forest sector, will jeopardize the objectives of the National Programme of Pulp and Paper, approved in August last year. Through the National Programme, Brazil aims to double its pulp and paper production in the next eight years. This digest is from _Brasil Florestal_ No 62 by Carlos A. Ferreira.

GREECE

The State Forest Service is run as a department of the Ministry of Agriculture. It has direct control of 1.6Mha or 66% of the total forest. It is involved with Research, Training and in Utilisation. The annual output averages 1.1m³/ha with a total cut of 2.7Mm³. Some 80 to 85% of the latter is small-wood including firewood. Private woodland owners have 8% of the closed forest, the 200,000 ha being composed of individual and group holdings in the order of 200 ha. The owner has to obtain annual felling licences as part of a five year plan of operations; he receives little State incentives but is subject to income tax, inheritance tax, forest duty and sales levy. Such agricultural loans as are available are for periods far shorter than the anticipated tree rotations.

SUDAN

A 6 ha woodlot for the village of Misiktab in the Nile Province of Sudan is one of the first benefits of funds raised by Tree Aid, a charity founded by foresters and the wood industry. The agency implementing the work, with the approval and co-operation of the villagers is SOS Sahel International. This particular project will cost about £7,000 spread over some four years of establishment. It is reported that the Overseas Development Agency is enhancing contributions by an equal amount. The forest management company of Tilhill has donated £2,500 in cash. Some of their staff are able to assist those with problems of establishment of trees on light soils lacking in fertility. Further information on Tree Aid may be obtained from Roger Busby, Ridgeway House, 6 Ridgeway Road, Long Ashton, Bristol BS18 9EU.

TANZANIA

A Wildlife Conservation Society has been formed in Tanzania. A quarterly newsletter _Miombo_ is proposed. It is hoped that a regional network will be able to foster conservation throughout the country. Further details may be obtained by writing to their Secretary, PO Box 70919, Dar es Salaam, Tanzania.
VANUATU

Vanuatu is a small country comprising some 80 islands scattered in a Y-shape in the South-west Pacific.

None of the islands is very large, Espiritu Santo the largest has an area of 4,000 km$^2$ with an impenetrable mountain range to the west which effectively covers over half the land area. Much of this type of difficult area has “dark bush”, where other parts have more open vegetation mostly consisting of widely scattered trees in a matrix of vines and heavy thicket. This presents difficult terrain to negotiate. Plantation agriculture covers much of the remaining area, on Santo, some 700 km$^2$.

No Inventory of the Forests has been undertaken (other than a few small specific studies) but this is to be remedied over the next few years.

A project is in the pipeline for a National Forest Resources Survey/Inventory which is to be funded by Australia and will be jointly under-taken by Vanatu and Australia. It will take three to four years following the start which has already been made. It will give the Vanuatu Forest Service much valuable information and will enable the Integrated Forest Management and Conservation Plan to be written.

Although Vanuatu is close to PNG, Solomons and Fiji it is by comparison very poor in quality timber (much timber defect with shake and rotten heart), light stocking, diversity of species and poor accessibility. Many hopeful logging companies (both well and poorly managed) have come to grief and ruin in Vanuatu with many bad debts left behind and an unhealthy image left with the local people.

The following is taken from a recent description of the sector.

“Commercial timber exploitation began in the early nineteenth century with the cutting of sandalwood. There has subsequently been numerous logging and saw milling ventures concentrating mainly on Agathis macrophylla (Kauri) forests. These species have now been largely exhausted.

Although some 75 per cent of the nation’s land area is under natural vegetation, much of it is too steep for logging or contains little valuable timber. Forest resources are poor compared with those of neighbouring countries, due to geological youth, geographical isolation, previous hurricanes and shifting cultivation — the end result being low volumes of merchantable species which are, for the most part, slow grown.

There has been a trade imbalance in timber for many years and this situation is unlikely to alter as the natural forests are unable to support a sustained and profitable logging and forest products industry of a significant size. Self sufficiency in timber products can only be obtained on a sustainable basis with plantation timber.”

At present there is a 5 year Moratorium on the cutting and export of sandalwood. No timber is allowed to be exported in log form (except Antiaris toxicaria by Ni-Vanuatu companies only up to 31 December 1988) and perceptions are rooted in value added processes in the country for the meagre resource that still remains.

Controls on logging are rigid, and licences are restricted in number to protect the future of the small local processing industry.

The way forward is through plantation forestry. Following much research effort the two main species Cordia alliodora and Pinus caribae var hondurensis have been identified as good growing and substantially cyclone proof. Mahogany (Swietenia macrophylla) and Kauri (Agathis macrophylla) also show much promise.

Having completed the National Forest Inventory and the Integrated Management and Conservation Plan in 1992 Vanuatu will then be able to utilize its resources objectively.
Until then the conservation of the growing resource is the key policy that is to be adopted.

This report by John Jenks has been forwarded from the Department of Agriculture, Livestock and Horticulture.
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POINTS OF DEPARTURE FOR SILVICULTURE IN HUMID TROPICAL FORESTS

By I. D. HUTCHINSON*

SUMMARY

Each established silvicultural system for tropical forests reflects its time and place of origin. There is much to be learned from these systems, but it is dangerous to apply them without modification to forests about which little is known. Instead, it is preferable to begin by testing the forest’s reactions to individual silvicultural operations and to simple improvement treatments. This approach will rapidly provide reliable information upon which to develop a suitable silvicultural system.

Introduction

In some regions, the known tropical silvicultural systems are frequently studied, and sometimes taught, as if they were packages to be applied unchanged to forests about which little is known.

To reduce the risk of misleading and costly results from this limited approach, this paper suggests that silvicultural investigation in little-known areas of tropical forest begins by observing the results of individual silvicultural operations. Once the consequences of an operation are sufficiently well known to be forecast with reasonable certainty, different operations may be pieced together to form a tentative “silvicultural system” which may then be applied and tested as a unit.

It is sometimes not recognised that an established silvicultural system portrays a level of silvicultural development in a given area and represents a considered course of technical action in response to the conditions of a given period (Wyatt-Smith, 1986). Relevant conditions include those affecting vegetation, site, timber market, official policy and administration, labour supply, staff training, population pressure (or the absence of it), and the use and tenure of land.

* APFAF, 7170 CATIE, Turrialba, Costa Rica
Therefore, to apply an established silvicultural system without carefully examining the reasons for its components, may give rise to a series of long-term problems. This is not to say that nothing can be learned from a study of the established systems. On the contrary, these systems teach a lot, but often their most useful lessons are not immediately obvious.

For instance, Trinidad shows the significance of protecting wildlife in connection with natural regeneration (Baur, 1964). The handful of systems developed on islands (Andaman, Reunión, Solomons and Trinidad) reveals the influence of a local awareness of finite resources and of a local demand for forest products, suggesting that initial trials and demonstrations in undeveloped regions could profitably be situated near centres of population where similar localised conditions already exist or could be developed. Similarly, the outstanding contribution from Malaya could well be the concept of a constant flow of forest information from a specialised periodic sampling, rather than the purely silvicultural techniques.

Furthermore, it is worthy of note that many silvicultural systems were originally intended to be applied over extensive areas of forest protected and administered by the State. Today, circumstances oblige the tropical forester to think in terms of potential and viable silvicultural systems which are appropriate to small areas often under pressure from other forms of land use. These may be owned and managed by civic authorities, co-operatives, small industries, or by individual farmers capable of investing little more than their own labour.

On first thought, the phrase “forests about which little is known” could perhaps be interpreted to apply only to tracts in regions such as Amazonia. But the situation in regions which have been largely deforested is critical because often there exists little or no useful information on the vestiges of forest which survive. In such places it is urgent that silvicultural approaches — within the reach of small landholders — be developed to establish an enduring place for logged and secondary forests in the social and economic fabric of the nations concerned. Suitable silvicultural approaches will lead to recognition of the economic value of a forest, a basic factor contributing to support the concepts of conservation and management of forest resources.

**Historical Background**

It is useful to observe that some of the established silvicultural systems were preceded by a series of exploratory operations and techniques which were often applied for years before any satisfactory system evolved. Today, some of these trials appear arbitrary, but it is clear that, in an era of less comprehensive knowledge of ecology and experimental design, they served as probes by which to establish the foundations for the systems which followed. Thus, it is not an admission of weakness to follow, perhaps in part, a parallel process of development. Some such trials are noted below, the information having been drawn from Baur (1964).

**Malaya:** At the beginning of the century, Malayan forestry concentrated on a single species, *Palaquium gutta*. Later, with an expanding timber market, silviculture favoured an increasing number of commercially desirable species and began to induce their regeneration. During the 1920's Regeneration Improvement Fellings were developed and applied. Improvement treatment removed overmature trees. Young trees were thinned and undergrowth cleaned.

During this period, the vital importance of a flow of technical information for silviculture and management was recognised, and procedures for strip sampling were instituted in 1935. Data from this type of sampling, together with a broadening market and a mechanised and more concentrated logging, led to the following results:
Silviculture in Tropical Forests

a) regeneration was no longer induced because it was seen that an adequate stocking of the regeneration of desirable species already existed in the forest
b) it was seen that excessive cleaning of the understorey set back the ecological succession (Mead, 1937)
c) many of the commercially desirable species were observed to be light-demanders

In 1950, the Malayan Uniform System was formally applied, incorporating the periodic and quantitative “diagnostic sampling” (Cousens, 1958; Wyatt Smith et al., 1963). The system was modified in 1957.

Nigeria: During the 1920s, logging was regulated by a minimum cutting diameter. The stocking of natural regeneration was observed to be deficient. A series of operational procedures were tested, often focussed on seedtrees. Clearfelling followed by burning created climber tangles. Trials of cleaning and thinning were found to be both too labour intensive and too dispersed.

In 1944, the first version of the Tropical Shelterwood System was applied with the aim of establishing prior to logging sufficient trees of desirable species to form the basis of a future harvest. Periodic sampling of the natural regeneration began and was continued thereafter. The system was modified during 1953–56, and again in 1961, with the aim of reducing the number of operations, removing old and defective trees, attempting to control lianas, and ceasing treatments of the understorey because the stocking of commercially desirable saplings was being accidentally but consistently reduced. The Nigerian approach applied a numerous labour force upon frequent and intensive operations. Equivalent conditions may not exist elsewhere in the tropical world.

Trinidad: The Trinidad Shelterwood System was developed on a site devoted to agriculture from 1890 to 1927. Early operational tasks included the elimination of existing vegetation, burning, and establishing a forest plantation. Dense grass captured the site after burning. An agroforestry approach proved too costly. Trees planted beneath existing forest canopy did not prosper.

In 1936, the presence of adequate natural regeneration was noted. By 1939, shelterwood principles had begun to be applied. The important role of birds and bats in bringing tree seed to the forest was observed. Taking advantage of the demand for wood, both green and dry, to produce charcoal, trees in the upper storey were spaced as evenly as possible, giving rise to the Shelterwood System, formally applied in 1941. The system was modified in 1945 and again in 1950.

Silvicultural Operations

A silvicultural system for tropical forest is made up of a series of individual operations, each of which contributes towards the objectives of the system. In spite of differences in detail, these operations are commonly applied throughout the tropics. They can be regarded as basic to treatment, and used to explore the dynamics of a tropical forest as part of the process of developing a suitable system.

Silvicultural operations may be grouped as shown below.

1. Harvesting: It is vital to note that selective logging alone is not sufficient to cause a uniformly positive reaction from advance growth or natural regeneration. To obtain maximum productivity, logging damage should be reduced to a minimum and harvesting be followed by suitable and previously planned silvicultural treatment. However, the canopy opening and the infrastructure left by logging are important.
2. Removal of impediments: Taking advantage of logging’s infrastructure, this operation seeks to free surviving trees and saplings of desirable species from the competition of woody climbers and trees of species not commercially desirable.
Woody climbers commonly severed: however the only effective control is by means of canopy shade. Rarely do palms have to be regarded as impeders.

3. Soil treatments: These comprise controlled burning and soil scarification, with the aim of preparing a seedbed for the natural regeneration of commercially desirable species. Neither is commonly applied, though a certain amount of scarification occurs in the course of selective logging with heavy machinery. As land use pressures increasingly confine production forestry to difficult sites, it is possible soil treatment may become more widely applied.

4. Canopy opening: This may be effected by (a) the judicious cutting of woody climbers, (b) thinning one or more of the canopy levels. Canopy opening is the most important treatment in tropical forest because it offers a means by which to remove undesirable individuals and species, and to provide the space and illumination needed by advance growth and regeneration. Usually, greatest effect is achieved by thinning the middle canopy. Unwanted trees are poison-girdled where (a) there is no market for their wood, (b) logging damage to seedlings and advance growth is to be avoided, or (c) a gradual opening of the canopy favours the advance growth of important commercially desirable species.

5. Liberation: Acting upon the results of sampling, liberation releases young growth from the competition from commercially less-desirable species. The aim is to assure maximum and constant growth of the young trees of desirable species. Bryan (1981) states that trees given good crown illumination in youth can be expected to grow at a maximum rate until harvest. Unless comprehensive experimental controls have been provided, the positive effects of silvicultural treatment in natural forest may not be readily apparent. But, growth response apart, liberation is valuable in avoiding much of the natural mortality of desirable species which would otherwise occur. It stabilises the population of young trees of the commercially-desirable species at higher levels than possible in untreated forest.

6. Refinement: This operation removes trees from the stand exclusively because of their species. It does not consider either possible changes in the timber market, or the fact that trees not currently merchantable may play a useful role in the stand with regard to (a) height growth and self-pruning of trees of desirable species, (b) their shade to influence the tree species regenerating and to inhibit the growth of vines or bamboos, (c) soil protection and nutrient cycling.

7. Cleaning the lower storey: This operation increases illumination at ground level, inducing germination of desirable species, and stimulates seedlings and saplings. Cleaning is costly and subject to error and carelessness in species identification. Excessive cleaning may set back the ecological succession (Mead, 1937).

8. Sampling: This operation permits management decisions to be both flexible and exact (Wyatt Smith, 1962). In the managed forests of Malaya thirty years ago, sampling intensity and plot size of diagnostic sampling changed in accord with the time elapsed after treatment and the anticipated growth of the vegetation of prime interest. However, in unmanaged forest, experience suggests that preliminary decisions on the type and intensity of operations and treatments can be derived from diagnostic sampling integrated with a conventional inventory, with plots of 10×10 metres (representing a potential stocking of 100 final-crop trees per hectare) in which the intensity of the illumination of the crowns (Dawkins, 1958) of leading desirables has been recorded (Hutchinson, 1986a).

9. Thinning: In a previously treated stand, thinning is usually applied among trees of species which are commercially desirable. In such cases, decisions are guided by the relative qualities of neighbouring trees. Wherever possible, the yield from thinning should be utilised. It is advisable to supervise the operation closely to ensure that
losses due to the felling and extraction of thinned stems are kept to a minimum.

**Improvement Treatments**

By removing stems which are old, defective, and of no commercial value, improvement treatment aims to provide more space for trees of desirable species. In natural forests not previously managed, improvement treatments are of prime importance. They represent the first step towards improving the quality and raising the productivity of the resource. The latter is one of the most urgent needs in tropical forestry (Wadsworth, 1987). Without improvement treatments, any other silvicultural measure has only a limited chance of success.

Observations recorded on the effects of improvement treatment contribute to the information necessary to begin silviculture and management. Furthermore, improvement treatments possess a socio-economic importance which should not be overlooked. They need not be technically difficult to apply: they are a useful source of rural employment with many long-term multiplier effects. They are not costly: return upon investment should be considerable. Perhaps a point of major importance is that they demonstrate land occupancy and potential productivity, thus acting as a deterrent to shifting cultivators and other interests seeking a change in land use.

Examples of improvement treatment are given below.

1. The Congo: This treatment is widely known as "uniformisation par le haut". Based upon intensive enumeration, it sought to favour the regeneration and growth of desirable natural regeneration by severing vines, and selected small stems, to an intensity indicated by the enumeration. It was expected that after 10–20 years, the forest would have developed to a condition suited to a selection system.

2. The Ivory Coast: Treatment in these forests followed the principles established in the Congo, but paid closer attention to favouring natural regeneration.

3. Liberation Thinning: Originating from Puerto Rico (Wadsworth, 1969) this improvement treatment has been successfully applied in Malaysia (Hutchinson, 1979, 1986a, 1987). Applied to forest after it has been selectively logged for the first time, it embraces the following:
   a) Poison-girdling all old and defective trees larger than the minimum cutting diameter, and of all commercially-undesirable species larger than a specified dbh. It is recognised that, in some forests, these large poisoned stems may function as climber towers for a brief period before falling to earth.
   b) Selecting potential final-crop trees from the advance growth, and freeing them from woody climbers.
   c) Poison-girdling those trees of non-commercial species which overtop or otherwise compete with a selected final-crop tree now, or will in the foreseeable future.

   The resulting canopy is relatively uniform in height. Openings created by logging and the treatment exist, but most are not extensive and favour gap-opportunistic species rather than woody climbers and the light-demanding tree species.

**Points of Departure for Silviculture**

A practical study of the reactions of a forest type to different silvicultural operations will assist towards identifying the principal problems to be encountered in little-known forests. These reactions can then be pieced together to form what may later become a functioning and cohesive silvicultural system. In other words, the reactions to different
silvicultural operations provide points of departure for the eventual development of a suitable silvicultural system.

For example, as shown below, such points of departure may be grouped with the intention of orienting and placing in sequence the tasks to be undertaken in areas of tropical forest about to be brought under management for the first time.

Observations suggested:

a) Analyse the possible influences on silviculture and management of factors such as population pressure, land use and tenure, and the existing responsibilities for protecting and administering the forest resource. This will assist towards defining the objectives of management.

b) Analyse and evaluate markets, present and potential. Identify local and regional centres of consumption. Study them with the aim of meeting demand from the production of surrounding forests.

c) Assemble information on the physical properties of the woods of tree species actually and potentially commercial. If published data does not exist, it may be necessary to dispatch specimens to a laboratory. Group the species in the forest according to their level of merchantability as well as colour and density. This will help identify the aims of management, simplify the interpretation of inventory results, and suggest the silvicultural operations to be tested.

d) Using available information, divide the commercially desirable tree species into ecological groups, paying particular attention to those which are obviously light-demanding and to those clearly shade-tolerant. Knowledge on this subject will begin to convey an impression of the nature of the silvicultural treatment required to favour the majority of the species of interest. It is likely that valuable information, not available from other sources, may be obtained by sampling tracts logged in earlier years. No silvicultural system can be applied positively until the ecological reaction of the principal species, considered as a group, can be forecast at least in a general way (Hutchinson, 1980).

e) Gather indicative information on the means by which the seeds of the principal commercial desirable species, as well as those of the light-demanding species, are distributed.

f) Assemble inventory information on the structure and composition of each important forest type, especially with regard to the presence of old and defective trees; intermediate trees of commercially desirable species; natural regeneration of commercially desirable species; woody climbers, bamboo, and palms; and the implications of the effects of hurricanes, floods, drought, fire, and geomorphological processes.

Pilot Experiments and Demonstrations

a) Apply improvement treatments where appropriate. Observe the effects, measure the growth reactions, and keep an account of costs.

b) Test the effects of controlled burning, scarification, canopy opening, and cleaning of the lower storey upon the inducement of natural regeneration.
c) Where a market exists for wood in small sizes, test the feasibility of employing, for suitable species and products, either a coppice system or one of coppice with standards. The latter, while supplying wood for fuel and local construction, can meet the needs of an industry established on quality woods produced from the standards, (Smith, 1962; Hutchinson, 1986b).

d) Test the constructive role in silviculture of the light-demanding species, and those not commercially desirable. That is, observe their usefulness as a nurse crop for desirable species, their contribution towards the species composition of the natural regeneration, the height growth and self-pruning of desirables, the control of vines and bamboos and the protection and the quality of the site.

**Conclusion**

Where little silvicultural information exists for previously unmanaged forest, trials of individual silvicultural operations and of simple improvement treatments offer a means by which to provide quickly the information which can lead to the development of a suitable silvicultural system. The identification of points of departure from which to begin trials is an important step in the process.

**REFERENCES**


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TROPICAL FOREST GENETICS AT THE OXFORD FORESTRY INSTITUTE

By R. D. BARNES*

SUMMARY

Work began in 1963 at the Commonwealth Forestry Institute on the genetic development of Pinus caribaea. A sequence started with exploration of the natural distribution, a study of variation through classical taxonomic procedures backed up by chemotaxonomy and observations on general morphology. Seed was collected to cover the range of variation, then processed, tested and stored in England and distributed for trial in recommended sites and designs. Evaluation of performance followed, with the concurrent development of assessment techniques. Analysis, interpretation and publication of the data were completed. Then, using these results, new seed (and scion) collections from the natural stands (and from the provenance trials themselves) were made, with sampling now structured in such a way as to gain a better understanding of variation in the most promising provenances and to provide material for the creation of breeding populations. Appropriate breeding strategies were evolved and practically implemented through direct advice to participating countries and a philosophy was developed for the conservation of genetic diversity both in situ and ex situ. This work with P. caribaea created the capability in the form of specialist staff and facilities at the now re-named Oxford Forestry Institute for the genetic development and conservation of a species. As current needs have been indicated by world forestry fora, more species have been brought into the programme including other tropical pines, various tropical and sub-tropical hardwoods, and dry zone species for multipurpose use in agroforestry and silvo-pastoral systems. During the past 25 years the Oxford Forestry Institute has distributed over 22,000 separate seedlots of 108 species to 122 countries. Expansion of the OFI's embryo gel electrophoresis and tissue culture laboratories is seen as an important step in the future to increase the efficacy and speed with which tree species can be conserved and bred. There is an urgent need to identify and develop indigenous species to increase the productivity of non-arable land in the dry tropical regions of Africa.

RÉSUMÉ

En 1963 des travaux ont commencé au Commonwealth Forestry Institute sur le développement génétique de Pinus caribaea. Une séquence a commencé avec l'exploration de l'aire naturelle, une étude de variation par des procédés classiques de taxonomie soutenue par la taxonomie chimique et des observations de la morphologie générale. Des graines ont été recueillies pour embrasser l'étendue de la variation, puis traitées, testées et emmagasinées en Angleterre et distribuées pour être mises à l'essai dans des endroits et desseins recommandés. L'analyse de performance a suivi, avec le développement simultané de techniques d'évaluation. L'analyse, l'interprétation et la publication des données ont été achevées puis, en utilisant ces résultats, des nouvelles récoltes de graines (et de greffons) des peuplements naturels (et des essais de provenances eux-mêmes) ont été faites, avec l'échantillonnage maintenant structuré pour acquérir une compréhension améliorée de la variation dans les provenances les plus encourageantes et pour fournir du matériel pour la création de populations d'amélioration. Des stratégies appropriées

* Oxford Forestry Institute
d’amélioration ont été élaborées et mises en œuvre par des conseils directs aux pays participants et une philosophie a été développée pour la conservation de la diversité génétique et in situ et ex situ. Ce travail avec *P. caribaea* a créé la capacité en personnel et équipement spécialisés au maintenant rebaptisé Oxford Forestry Institute pour le développement et la conservation génétiques d’une essence. Quand les besoins courants ont été indiqués par des forums internationaux de foresterie, encore d’essences ont été incorporées dans le programme, y compris des autres pins tropicaux, des bois de feuillus variés tropicaux et subtropicaux, et des essences des zones arides à buts multiples dans l’agrosylviculture et des systèmes sylvo-pastoraux. Pendant les 25 ans qui viennent de s’écouler l’Oxford Forestry Institute a distribué plus de 22,000 lots de graines de 108 essences à 122 pays. L’expansion des laboratoires d’électrophorèse sur gel d’embryons et de multiplication *in vitro* d’OFI est considérée comme une démarche importante pour améliorer l’efficacité et la rapidité avec lesquelles des essences forestières peuvent être conservées et améliorées. Il y a un besoin urgent d’identifier et de développer des essences indigènes pour augmenter la productivité de terrain non-cultivable dans les régions tropicales arides d’Afrique.

RESUMEN

El trabajo en el desarrollo genético de *Pinus caribaea* se inició en el Commonwealth Forestry Institute en 1963. Se comenzó una secuencia mediante la exploración de la distribución natural, un estudio de la variación a través de procedimientos taxonómicos clásicos apoyados por técnicas quimiotaxonómicas y con observaciones sobre la morfología general. Se recolectó semilla para cubrir el ámbito de la variación y esta se procesó, probó y almacenó en Inglaterra y posteriormente se distribuyó para el establecimiento de ensayos, en sitios y con diseños recomendados. Se continuó con la evaluación del comportamiento, lo que a la vez condujo al desarrollo de técnicas de evaluación. Se completó así el análisis, interpretación y publicación de la información y con el uso de estos resultados se realizaron nuevas colecciones de semilla (y yemas) de los rodales naturales (y de los mismos ensayos de procedencias); ahora el muestreo está estructurado de una manera tal que permite obtener el mejor conocimiento de la variación en las procedencias más prometedoras y proveer material para la creación de poblaciones de mejoramiento. Se desarrollaron estrategias de mejoramiento apropiadas e implementadas en la práctica mediante la asesoría directa a los países participantes y también se desarrolló una filosofía para la conservación de la diversidad genética tanto in situ como ex situ. Este trabajo con *Pinus caribaea* creó la capacidad en la forma de personal especializado y facilidades en el ahora llamado Oxford Forestry Institute, para el desarrollo genético y conservación de una especie. Las necesidades actuales, tal como ha sido indicado en los foros forestales mundiales, condujeron a que se incluyeran más especies en el programa, entre ellas otras especies de pinos tropicales, varias especies latifoliadas tropicales y subtropicales, y especies de zonas secas para uso múltiple en sistemas agroforestales. Durante los últimos 25 años, el Oxford Forestry Institute ha distribuido más de 22,000 lotes de semillas de 108 especies a 122 países. La expansión de los laboratorios de embrio gel electroforesis y de cultivo de tejidos, se ven como pasos importantes en el futuro para incrementar la eficiencia y velocidad con la cual las especies forestales puedan ser conservadas y mejoradas. Existe una necesidad urgente para identificar y desarrollar las especies indígenas, como un medio para incrementar la productividad de la tierra no arable en las regiones tropicales secas de África.

**Introduction**

In 1962, the Committee on Silviculture to the Eighth Commonwealth Forestry Conference reported that *Pinus caribaea* Morelet was being used increasingly for the
creation of softwood plantations in the tropics and that, because of its wide natural
distribution, there was an urgent need for a co-ordinated study of its races and
provenance characteristics (B.C.F.C., 1962). The Conference responded to this report
by passing a resolution recommending that a special study be initiated into the races and
provenances of *P. caribaea*, that interested countries should make arrangements for
co-ordinated seed collection and provenance trials and that the initiation and co-
ordination should be undertaken by the Commonwealth Forestry Institute (CFI) at
Oxford.

In September, 1963, 25 years ago this month, work started at the CFI on this *P.
caribaea* assignment with funds provided by most Commonwealth countries and the
British Overseas Development Ministry (ODM) for the establishment of the Unit of
Tropical Silviculture. An extensive taxonomic and silvicultural study of *P. caribaea* was
undertaken together with a literature review and published as a species monograph
(Lamb, 1973). Some seed was acquired for trials over the following five years. During
this period, the great importance of provenance, especially in view of the rapidity with
which natural forest was being destroyed, was recognized in various world fora such as
the First World Consultation on Forest Genetics and Tree Improvement (FAO, 1964),
the World Symposium on Man-made Forests and their Industrial Uses (FAO, 1967) and
the FAO I3P Technical Conference on the Exploration, Utilization and Conservation
of Plant Genetic Resources (FAO, 1968).

In 1968, a resolution of the Ninth Commonwealth Forestry Conference (B.C.F.C.,
1968) recommended that work on species and provenance trials be vigorously continued
and, in response in 1969 the ODM with additional support from FAO funded a project
on *P. caribaea* to explore the natural populations, distribute seed for international
provenance trials and initiate measures to conserve the potentially valuable and
threatened populations (Kemp, 1973).

Over the following eight years, in a series of ODM-funded projects, further studies on
natural distribution (Robbins and Hughes, 1983) and variation were conducted using
classical taxonomy (Stead and Styles, 1984; Styles and Hughes, 1983), chemotaxonomic
(Burley and Green, 1978) and electrophoretic (Matheson *et al.*, in press) methods and
seed was collected from over 40 provenances of *P. caribaea* (Greaves, 1978), processed
and tested for the CFI at the Forestry Commission’s seed store at Alice Holt, and
distributed for provenance evaluation in many hundreds of trials planted according to
CFI recommendations (Burley, 1969) spread over 50 countries. During this period,
many participants in the international trial series sent their requested periodic
assessment data (Burley and Wood, 1976) to the CFI and, in 1978, these were analysed
and reviewed (Greaves, 1980).

By 1979 a large number of the first comprehensive trials had reached seven years.
After this age, the value of data yielded by tropical pine trials starts to be prejudiced by
competition and thinning. It was realized that, if they were to yield information to their
full potential, especially that on provenance-environment interaction, a co-ordinated
assessment procedure must be adopted (Barnes *et al.*, 1983). Consequently, ODM, by
then the Overseas Development Administration of the Foreign and Commonwealth
Office (ODA), funded two three-year research schemes at the CFI during which
detailed assessments were carried out by CFI research officers in co-operation with staff
from countries hosting a set of trials selected for their age, distribution,
comprehensiveness and condition. A sampling and assessment methodology was
developed (Barnes and Gibson, 1984; Birks and Kanowski, 1988) and data on
morphological, phenological, wood and chemical traits analysed, interpreted and
published (*e.g.* Gibson, 1982; Barnes *et al.*, 1983; Gibson *et al.*, 1983a and 1983b; Birks
and Barnes, 1985; Wright *et al.*, 1986 and 1987). At this stage it became possible to
indicate the size of the economic benefit that could be realized through genetic development (Plumptre and Barnes, 1982).

The co-ordinated assessments indicated which provenances were best adapted to which exotic environments and it was possible to concentrate on seed stand selection and management in the natural stands of those with most potential (Hughes and Robbins, 1982). The assessments also showed that the greatest source of variation was between trees within provenance, rather than between provenances, and that this characteristic itself varied greatly between provenances. Consequently, a second round of collection from selected trees in the provenances that had performed best in the trials was undertaken in a further ODA-funded research scheme and this seed was used to establish second stage provenance progeny tests that were also designed to serve as a selection base for the creation of breeding populations (Barnes et al., 1982). The evaluation of these trials is at present being undertaken by the most recent ODA-funded Research Scheme with the objective of assessing the value of maintaining half-sib family identities of trees selected in natural populations for providing information and materials.

On return to the natural stands of the most promising provenances of *P. caribaea*, it was found that some stands had suffered serious genetic depletion since the first seed collections were made and others had become inaccessible for security reasons. Thus, not only were the provenance trials a valuable resource in that the trees in them represented the genotypic response to a new environment, but they were also in some instances now the best source of material of that particular provenance anywhere. However, one or two superior trees, superb as they sometimes were, were not enough on their own to form the basis of a breeding population — but assembled over all the trials, they could form a valuable basis for a breeding programme. A project was therefore formulated to assemble vegetative material from the best individual genotypes in the *P. caribaea* provenance trials in a greenhouse at the OFI field station at Wytham near Oxford, and bulk up the material, if possible by tissue culture in the laboratory in an environment free from pests and diseases. Clonal breeding populations would then be distributed by scion or rooted cutting to regional centres throughout the tropics, whence individual countries could acquire seed or scions for use in their own breeding programmes. This project was started in 1986, funded by the Shell Petroleum Company.

At the beginning of this 25-year period, many countries had just launched tree breeding programmes with tropical pines using the classical recurrent selection strategy i.e. selection of plus trees and seed production from progeny tested clonal orchards. Although in many cases spectacular first generation gains were made, breeders failed to capitalize on these, and on the large amount of new material that was being identified in the provenance trials, mainly because the strategy was inflexible and did not practically permit the maintenance of a suitably broad genetic base, the exploitation of genotype-environment interaction (Barnes, 1984a) or the incorporation of this new material into the breeding populations (Barnes, 1984b). From 1980 onwards, therefore, the ODA-funded pine projects at the CFI included in their objectives research into breeding strategy and this led to the theoretical (Namkoong et al., 1980a; 1980b; 1980c) and practical (Barnes, 1984b, 1986 and 1987) development of the multiple population breeding concept.

As the great variation within *P. caribaea* was revealed by the international provenance trials, as the constant erosion of the genetic resource in its natural range became apparent, and because of the risk of national breeding programmes being based on very small populations, conservation of genetic diversity also became a concern and an objective in the CFI genetics projects. Conservation *in situ* has been promoted on the grounds that the indigenous resources, despite the existence of excellent breeding
programmes based on exotic plantations, will continue to play an important role in the
 genetic development of the species far into the future (Barnes, 1985). Conservation ex situ has been built into the multiple population breeding strategy (Barnes et al., 1982). In addition seed has been distributed from the CFI with FAO/UNEP DANIDA ODA funding specifically for the establishment of ex situ conservation (Wood and Burley, 1983) and provenance resource stands (Gibson and Barnes, 1985).

Soon after work started on exploration of the natural range of *P. caribaea*, it was realized that other tropical pines in Central America had potential as plantation species. Most of these had found their way into tests from seed collections made in Mexico, but there was growing evidence that there was much more promising genetic material in the hitherto untested and unexplored southern extremities of their ranges. *P. oocarpa* and *P. patula* ssp. *tecunumanii* (Greaves, 1979, 1980 and 1982; Barnes and Styles, 1983; Styles, 1976 and 1985; McCarter and Birks, 1985; Wright et al., 1986 and 1987) were next to be included in the CFI genetics programme followed by *P. maximinoi* and *P. pseudostrobus* (Stead 1983a and b; Stead and Styles, 1984), then the southeast Asian tropical pines, *P. merkusii* (Cooling, 1968; Barnes and Gibson, 1984) and *P. kesiya* (Armitage and Burley, 1980; Gibson and Barnes, 1984). The potential value of the closed-cone group of pines of Mexico and Central America, viz. *P. oocarpa*, *P. patula*, *P. patula* ssp. *tecunumanii*, *P. greggii* and *P. pringlei*, was recognised (Barnes and Styles, 1983). In pure species or in hybrid combination they can provide suitable material for plantation development over a great range of environments in the tropics and together are likely to become the most widely planted tropical pines. A two-phase project is at present under way at the OFI, funded by the EEC Science and Technology for Development Programme, in which seed is being collected from selected trees in selected natural populations for the direct development of breeding populations both inside and outside the region.

Early results from the pine trials started to show that they were not successful as a replacement crop for tropical high forest, especially on the better sites and where conditions were conducive to continuous growth. At this point *Cordia alliodora* (Stead, 1980; Greaves and McCarter 1988 and in press), *Cedrela odorata* (Lamb, 1968; Burley and Lamb, 1971; Chaplin, 1980), *Agathis robusta* (Whitmore, 1977; Bowen and Whitmore, 1980) and *Liquidambar styraciflua* (McCart er and Hughes, 1984) were brought into the CFI programme successively, through more ODA-funded Research Schemes.

By the late 1970s attention was turning to planting trees to meet the needs of rural communities (FAO, 1977; World Bank, 1978). There followed an increasing realization that exploration and collection of gene resources and genetic development of species for non-industrial uses in rural communities was long overdue (Burley, 1980; Palmberg, 1981). By this time, the CFI had long experience in exploration and collection in Central America and therefore it was particularly well qualified to undertake this work with potentially useful species in the arid, semi-arid and seasonally dry zones of the region. This was again started and continues under a sequence of ODA-funded Research Schemes. Twenty-five species were identified as having potential for multiple-use in rural communities. These were *Acacia deamii*, *A. farnesiana*, *A. pennatula*, *Albizia guachepele*, *Alvaradoa amorphoides*, *Apoplanaea paniculata*, *Atleia herbert-smithii*, *Caesalpinia coriaria*, *C. eriostachys*, *C. velutina*, *Crescentia alata*, *Enterolobium cyclocarpum*, *Glicididia sepium*, *Guazuma ulmifolia*, *Haematoxylon brasileyto*, *Leucaena diversifolia*, *L. leucocephala*, *L. shannoni*, *Mimosa tenuiflora*, *Myropermum frutescens*, *Parkinsonia aculeata*, *Pithecellobium dulce*, *Prosopis juliflora*, *Senna atomaria* and *Simarouba glauca* (Hughes and Styles, 1984; Burley et al., 1986, Hughes and Styles, 1987; Stewart, 1988). Most of these species are represented in trials by only
one or two provenances with the exception of *Gliricidia sepium* of which a range-wide provenance collection has been made (Hughes, 1987a and 1987b) and the *Leucaena* species for which a range-wide seed collection of c. 15 species in the genus is nearing completion (Hughes, 1986).

As the result of a review of forestry research needs in developing countries presented at the Seventeenth IUFRO World Conference in Japan in 1981 (World Bank and FAO, 1981), IUFRO's special programme for developing countries was conceived, and subsequently a special co-ordinator was appointed who organized workshops in Asia, Africa and Latin America. The famines in the Sahelian and North Sudanian zones of Africa focussed attention on Africa and the World Bank and other international funding agencies turned to determining what research was required to increase the productivity of multipurpose lands in Africa (e.g. Burley *et al*., in press). IUFRO is currently holding a series of planning workshops in Africa (Carlson and Shea, 1986; Cossalter *et al*., 1988). The OFI genetics Group has responded by starting a series of projects on the genetic development and conservation of multipurpose species indigenous to Africa. The first of these projects, again funded by ODA, includes *Acacia (Faidherbia) albida*, *A. nilotica* (Greaves, 1984a), *A. senegal* and *A. tortilis* (Greaves, 1984b).

Thus, over the last 25 years the CFI has evolved a methodology for the genetic development and conservation of a tree species taken from the wild population to a breeding programme for its domestication for widespread use both as a native and as an exotic. Work with *Pinus caribaea* blazed the path but many other tropical species, softwood and hardwood, from moist to arid zones, have been brought into the programme; some, like *P. caribaea*, to be taken through the whole process, others to be a subject for only a part of the programme. Some idea of the scale of the research and development work is given by the sample of references that follows and by the fact that 22,000 separate seedlots (11,000 of them pines) of 108 species have been distributed to 122 countries for trial over the past 25 years. From one man and one project in 1963, the genetics group now consists of from 10 to 12 specialist professionals at any one time on 8 to 10 projects, each running for a period varying from 6 to 36 months, and each receiving some support from OFI core staff.

The generation of information from this programme has been enormous with a need, for example, to store descriptions of seed collection areas and trial sites, to link herbarium voucher specimens, to map species distributions, to match environments, to control seed receipts and dispatches, to store assessment data, to trace pedigrees and to maintain a network of past and present co-operators and their addresses. To exploit the full potential of all this information, an articulate database is required. SISTEM is operational and being developed and is the subject of a separate article in this issue of the Commonwealth Forestry Review (Filer, 1988). SISTEM stands for Species Information, Seed, Trial and Environment data Management.

Initially, a major part of the funding for the genetics work derived from contributions from Commonwealth countries but the proportion contributed, mainly by ODA, in the form of project-funding has increased over the years until now the Commonwealth contribution is very small by comparison. In 1985 the CFI was renamed the Oxford Forestry Institute (OFI) partly in recognition that the work of the Institute, while still being of direct application and benefit to Commonwealth countries, went far beyond its bounds in input to, and output from, both training and research. The countries of Central America in particular have contributed enormously in terms of the material and facilities provided and over 100 countries have offered sites and paid for the establishment and maintenance of tests.

What of the future? Although there is no substitute for the meticulous classical and traditional steps of taxonomy, seed collection, field testing and evaluation that have been central to the OFI's genetic development procedure for any species, development
of its embryo gel electrophoresis and tissue culture laboratories would make a significant contribution to the efficacy and rapidity of conservation and breeding. Information about mating systems, gene flow and population structure is the key to being able to design effective strategies through a study of isozyme variation to estimate levels of inbreeding, distance and rates of outcrossing, and between and within population variation. New techniques in biotechnology could hasten progress; clonal micro-propagation, tissue culture and DNA technology all have important practical applications in the future domestication and genetic development of tree species (Burley, 1987). The aim must be to achieve a balance in the exploration and collection of genetic resources in various environments and geographic areas for development to fulfil the multitude of roles that trees play in conservation, protection and production. Perhaps the most urgent current need is for tree species to increase the productivity of non-arable land in the dry tropics, particularly in Africa. To achieve this, exploration, testing and development of the species indigenous to the continent is worthy of much closer attention.

REFERENCES


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A DATABASE FOR TREE IMPROVEMENT AND SEED BANK MANAGEMENT: SISTEM

By D. L. FILER*

SUMMARY

A database known as SISTEM (Species Information, Seed, Trial and Environment data Management) has been established as an integral part of the tropical tree improvement research projects that are being co-ordinated from the Oxford Forestry Institute. Data is stored in five subject areas which are inter-related. These are seed management, trial management, herbarium specimen management, environment data and addresses and mailing. The seed collection and distribution cycle is central to database operation and provides a link between these areas. Routine and hitherto time consuming tasks such as seed stock control, compiling seed stock summaries, preparing trial descriptions, printing herbarium labels and maintaining up to date lists of research collaborators have been automated and a range of data output with direct research value can be generated.

RÉSUMÉ

Une base de données appelée SISTEM a été établie pour faire corps avec les projets de recherche sur la génétique des forêts tropicaux qui sont coordonnés par l'Oxford Forestry Institute. Les données sont stockées dans cinq sujets connexes: l'aménagement des graines, la gestion des essais, les collections d'échantillons d'herbier, les données environnementaux et les noms et l'imprimerie des adresses. Le cycle de récolte et de distribution des graines est d'importance capitale pour le fonctionnement de la base de données et fournit un lien entre ces sujets. Des tâches courantes et qui jusqu'ici prenaient beaucoup de temps comme la gestion du stock de graines, la préparation de descriptions des essais, l'imprimerie d'étiquettes d'herbier et le maintien à jour de listes de collaborateurs de recherche ont été automatisées et une gamme de sorties de données avec des valeurs immédiates pour la recherche peut être produite.

RESUMEN

Se estableció una base de datos llamada SISTEM, como parte integral de los proyectos de investigación en genetica forestal tropical que están siendo coordinados por el Oxford Forestry Institute. La información está almacenada en cinco áreas temáticas relacionadas. Estas son manejo de semillas, manejo de experimentos, colecciones de especímenes de herbarios, informacion ambiental, y nombres y direcciones. El ciclo de coleccion y distribucion de semillas es central para la operacion de la base de datos y provee una conexion entre esas areas. Se han automatizado labores de rutina y que son a su vez demandantes de tiempo, tales como el control de las reservas de semillas, preparacion de descripciones de ensayos, impresion de etiquetas de herbario y mantenimiento de listas actualizadas de investigadores cooperantes, y a la vez es posible generar una variedad de productos de valor directo para la investigacion.

Introduction

Since 1962, The Oxford Forestry Institute (OFI) has been co-ordinating a series of research projects to investigate variation in tropical tree species and develop strategies for their genetic improvement (Barnes, 1988). Initial studies concentrated on industrial species, notably *Pinus caribaea* Morelet, *Pinus oocarpa* Schiede (Barnes et al, 1980) and the hardwoods *Cordia alliodora* (R. & P.) Oken (Stead, 1980), *Liquidambar styraciflua* L. (McCarter and Hughes, 1984) and *Cedrela* spp. (Chaplin, 1980). More recently, following the increased interest in trees for use in social and community forestry, over thirty non-industrial hardwood species have been investigated, notably, species of the genera *Gliricidia* and *Leucaena* (Hughes and Styles, 1984).

A central feature of this work is the establishment of international provenance and species trials. Extensive provenance seed collections from throughout the natural range of each species are made. The seed is distributed to experimental trials from a central seed store to assess growth, performance and variation in wood properties, and to investigate the significance of provenance-environment interaction. In addition, further information is collected and compiled through studies on the taxonomy, distribution, ecological amplitude and reproductive biology of each species with a view to building up a holistic picture of their genealogy.

During the course of these projects, a large repository of research information has accumulated. Taken alone, information on seed origins, storage, viability testing and the history of seed distribution to experimental trials, seed orchards, conservation stands or any other managed population type, constitutes a complex set of data. Together with information on the establishment, genetic composition, and management of trials, trial assessments, herbarium specimens, environment data from seed collection and trial sites, including long-term meteorological records, and, a comprehensive and dynamic list of research collaborators, the volume of data is considerable and requires careful data management.

Prior to computer assistance in the genetics projects, data of different types was held in separate, unrelated files and ledgers. Cross referencing was poor and the data was becoming increasingly fragmented. Consequently, simple enquiries were becoming time-consuming and more complex ones impractical.

An early attempt to provide structured access to this data used four indexed but unrelated files holding data on seed sources, seed distribution, trial sites and trial performance. These files and the FORTRAN programs that accessed them were collectively known as INTFORPROV (International Forestry Provenance Trials) and were described by Burley et al (1973). However, a far more interactive and flexible system was required both to manage the seed stock data and to link together effectively all other related research activities in a meaningful way.

SISTEM (Species Information, Seed, Trial and Environment data Management) has been developed to carry out routine data management tasks and to provide research workers with rapid, interactive access to useful information. The current range of database functions has gradually evolved in response to requests from research workers using the system. Many of these functions have automated simple but time-consuming tasks such as seed stock control, printing seed dispatch letters, preparing trial summaries recording herbarium transactions, printing herbarium labels and maintaining up to date mailing lists. In addition, given the extensive cross referencing that exists between normally unrelated data types, SISTEM is able to provide a unifying perspective on the research data and synthesize complex data reports which are of direct research value. The SISTEM database was previously known as OXFORGEN (Oxford Forest Genetics).
The aim of this paper is to outline the structure and practical applications of the existing database facilities and to mention its future development potential.

SISTEM structure and function

SISTEM was established in 1985 under a research scheme (R3881) funded by the Overseas Development Administration (ODA), using a network (hierarchical) database management system with access via FORTRAN programs, on the OFI departmental mini computer, a Data General MV 4000. Due to interest in the system from research collaborators outside the OFI, a version using the database package DBASE III PLUS (now DBASE IV) has been created that can run on IBM compatible micro-computers with a minimum disk storage capacity of 20 megabytes.

Data is held in indexed datafiles that are related to each other via common fields as appropriate. These files are accessed for data update or output through a series of program subroutines operated by selecting choices from sequential screen menus. No computer literacy is required to use SISTEM.

The structure of the database is outlined in Fig. 2. This diagram shows the different datafile types and how they are related using standard one to many relationships. Thus, one Country record can ‘own’ or be related to many Site, Metstation or Name records while each of these latter record types can only be linked to one Country record. The direction of the arrows indicates the one to many direction. This summary diagram displays the overall structure and relationships within the database. The field structure and key indexing fields of the files are not listed. File names are capitalized in the text.

The structure and operation of SISTEM are best discussed by separating out discrete functional areas shown by the enclosures marked A-E. These areas are seed management (A), herbarium specimen management (B), trial management (C), environment data (D) and addresses and mailing (E). Areas A, B and C were developed as separate databases prior to their merger into SISTEM. Although treated separately, these areas are not independent from each other. Country, Site, Plot, Seed, Herbarium Specimen, Name and Species files are common to more than one area.

Seed management

During the course of the tropical tree improvement research at the OFI, a very large number of seedlots has accumulated. This is primarily due to many seedlots being kept separate by individual tree (half sib collections). Several other organisations involved in forest genetics research have some form of computerized seed directory. A documented example is TREESEED set up by CSIRO in Australia (Wolf and Turnbull, 1982).

The seed management section records data concerning the acquisition, processing and storage of seed or other germplasm types such as scions or clones and monitors the history of this material in research programmes such as its distribution to research collaborators and use in experimental trials. Several thousand seedlots, some bulked collections and others from single trees, are currently being monitored.

Each Seed record contains basic collection information such as the collector name, collection date, the initial and current seed weights, the number of trees collected (in bulked collections) and notes describing seed bearing tree characteristics. A donor seed ID is recorded if seed comes from another seed bank or research programme. Seed records have a unique number. An OFI example is 1/86 which implies the first receipt in 1986.

The numbers 1/86/01, 1/86/02... 1/86/20 describe a half sib series from one locality. Half sib seed collections, scions and clones are stored in separate Sibs records. Sibs records can hold additional information specific to an individual tree such as tree number
and altitude. A Sibs record may be related to another thus recording a collection from a previously collected tree. Sibs records are always related to a 'parent' Seed record which records general seed collection data and provides a link to seed origin and identity.

Seed test data can be stored from germination, purity, moisture and weight determination tests satisfying ISTA regulations. Final test results can be calculated from these component tests. Alternatively, final test data can be entered directly.

Seed from half sib collections is occasionally bulked into a general provenance collection. Bulking records link donor and recipient seedlots and store the weight of each donation. As indicated in Fig. 2, Seed records are linked to several other record types. As indicated in Fig. 2, Seed and Sibs records are linked to several other record types.

The program can trace seed origins by checking for links from Site or Plot records, the former implying collection from an indigenous or unmanaged stand and the latter from some form of managed population such as a trial or seed orchard. The indigenous origins of a seedlot collected from a managed population can be found by first tracing back to find the seedlot distributed to the specific Plot record in question and then retrieving the linked site data, assuming this data is recorded. This cycle can be traced over any number of generations. The seed origin data held in SISTEM complies with OECD seed source requirements for certification. Seed records can also be linked to plots in the opposite direction (Seed—to Plot) thus recording the inclusion of a seedlot in a trial or other form of managed stand (see below).

SISTEM can trace the distribution history of any seedlot by looking for all linked Seed Allocation records and, in each case, retrieving linked Seed Dispatch, Name and Country records. Seed Dispatch records, which record the dispatch number, the dates of seed dispatch and arrival and, the category of trial the seed is to be used in, are linked to all those Allocation records which comprise the dispatch, and also to the seed recipient (Name record) and thus to Country records. Thus, all seedlots distributed to an individual, an institution or to a country can be listed. Automated seed selection, stock control, dispatch logging and the printing of seed dispatch, seed provenance and seed quality forms are important routine database functions. An example of a database screen for the selection of seed by species for dispatch is shown in Fig. 1.
Species records have separate fields for species code, family, genus, species, subspecies or variety and authority. They can also hold text describing pre-germination treatment and seed storage recommendations. By linking Seed records to Herbarium Specimen records, an important link between the concept of provenance and the known taxonomy of a species is formed. Voucher herbarium specimens are collected with seed whenever possible to ensure that seed collections are accurately identified. A bulked provenance seed collection may be linked to several herbarium specimens. Alterations in the determination of a herbarium specimen are automatically passed on to Seed records.

Thus, as well as listing basic seed collection details, SISTEM can check all related records and display seedlot origin, distribution history, use in trials, seed tests, species name, related herbarium specimens and any bulking received or donated.

In addition to these program facilities, several other seed related menu options are used frequently. These include listing stock by genus, species, region, country or provenance, listing the seed distribution history for a species, checking seed test recency, listing recipients of selected seedlots and a number of specialized seed stock summary reports.

**Trial management**

Co-ordinating the establishment of experimental trials is a central feature of the OFI tree
improvement research programme. The necessary seedlots and experiment design
instructions are dispatched to research collaborators who are then responsible for trial
initiation and management. Trial assessments are carried out by collaborators or by
visiting OFI staff and the assessment data centrally collated.

Several database systems are currently being developed to store and analyse data
associated with experimental trials. The Forestry/Fuelwood Research and Development
project (F/FRED) has created a system known as IADSS which is used in conjunction
with a network of experimental trials in Asia (Farm Forestry News, 1987). The tree crops
(Modelena) project at the Centro Agronómico Tropical de Investigación y Enseñanza
(CATIE) in co-operation with the College of Forestry at the University of Minnesota is
developing a system known as MIRA for use in Central America (Rose and Ugalde, in
press). The Forest Research division of CSIRO, Australia has created a system known as
TREDAT (Brown et al., 1987).

Although referred to as the trial management section, SISTEM can store data from
any type of managed population including experimental trials (species, provenance,
progeny), seedling seed orchards, clonal seed orchards or clone banks, provenance
conservation stands, provenance seed stands and seed production areas.

In SISTEM, Trial records store notes on trial type, objectives and experiment design;
nursery information including sowing date, the type of containers used, shading and soil
notes and removal date; and general trial data including planting out and replacement
planting dates, total area and spacing, the assessment plot size, the number of
replications, plot size and subtreatments as well as surround details and establishment
method. Nursery management and trial justification notes are stored in linked word
processor files.

Plot records, which link seedlots to trials, hold data specific to each treatment in a trial
including first germination date and germination %, transplanting and replanting dates,
the number of nursery pots, usable plants and the cull % and also various nursery growth
measurements. Trial measurement data is stored separately in Data records which are
linked to Plot records.

SISTEM can list all trials containing a selected seedlot or provenance by searching for
linked Plot records (Seed→Plot), and subsequently, for each plot, retrieving the correct
Trial record. Similarly, by retrieving all Plot records linked to a selected trial and their
owning Seed records, the genetic composition of a trial can be traced.

To obtain trial site and meteorological data, the owning Site record is retrieved. The
most appropriate meteorological data is selected by searching for neighbouring grid
tables (see below) or retrieving a related Metstation record. It is possible to list all
trials in a region, country or on a site or to list trials growing at a selected altitude or
within selected climatic regions.

Also linked to trials are Management Reminder and Management Event records.
Both hold a date and several lines of free text. Management duties can be entered in
advance. Users can access reminders for trials at a selected look ahead level. Similarly,
management events such as thinning, burning or the application of fertilizer can be
stored in the Management Event records which can subsequently be listed for trial
reports. Management Event records also hold the number of man days used and the cost
of the event. Man days and costs can be totalled by trial or site for reports.

Trial assessments are logged in separate Assessment records linked to each trial.
These records store a date and a coded list of the parameters measured. Trial
measurement data is stored in Data records which are related to Plot records. These
records store the replication number, an assessment number related to the Assessment
record, a data identifier, initially set to “1” and five fields for raw data. Should more than
five characters to be assessed, a further Data record can be stored, the data identifier
incrementing by one for each additional record. Thus a Data record with an identifier of 2 stores characters 6 through 10. The parameters measured at any assessment are stored, in coded form, in sequential fields in the Assessment records for that trial together with the date, their order matching their occurrence in the Data records. This technique ensures minimum space wastage. Data records can be retrieved in a variety of ways and fed into files in preparation for subsequent analysis.

**Herbarium Specimens**

Herbarium specimen data is ideally suited for database management and several significant herbarium database projects are currently in use (e.g. see Pankhurst, 1984). Taxonomic work forms an integral aspect of the OFI tree improvement projects providing an insight into the phenotypic variability and overall distribution of each taxon and a large number of herbarium specimens, often associated with seed collections, has been built up. For species of special research interest, notably the Central American pines and species of the genera *Gliricidia* and *Leucaena*, comprehensive specimen lists are being compiled from collections held at all major herbaria.

Herbarium Specimen records hold collection number and date, species common name, collection locality name, grid reference and altitude, photo number, codes for flowering and fruiting status, free text space for field notes and a text string holding the herbarium codes to which duplicates have been distributed. They are related to Species, Collectors Series and, where appropriate, Seed records.

When storing a specimen, the program ensures that all Duplicate records are stored and related to their respective Herbarium records. The Duplicate records hold a numerical species code indicating the determination supplied by the herbarium as well as the name of the botanist supplying this determination. A zero code implies no reply. A list of specimens sent to a selected herbarium or specimens for which no determination replies have been received can thus easily be retrieved.

A variety of menu options exist to interrogate this section of the database. Common uses are the printing of specimen labels, preparing lists by genus, species or collector, and creating lists using altitude, grid reference ranges or country sub regions as selection criteria.

**Site and environment data**

Environment data is collected as widely as possible from throughout the natural ranges of the species being investigated and from trial sites. During seed collection an attempt is made to encompass as much of the environmental variation as possible and to include sites at environmental extremes. As well as being useful in determining the ecological amplitude of each species, environment information is an important facet of trial interpretation.

Country records store country name and country code. In order to enable users to prepare reports such as seed stock summaries, herbarium collections or trial listings from specific groups of countries, Country records can be grouped into regions by linking them to Region records. Examples of regions are Central America, Africa, Southern Africa and South East Asia.

The Site record, to which both the Seed and the Trial records are linked, stores basic information such as country sub-region, grid reference ranges, altitude ranges, locality and access information and summarised soil data. In the case of trials, more detailed
information may be available such as past site use, site hydrology, topography and
detailed soil and geological data. If collected, this data can be stored in the Appendix
record.
Considerable attention has been given to the storage of climatic data. Metstation
records are stored by country giving grid reference and altitude, as well as a selection of
long term, absolute maximum and minimum climate values. Metdata records are linked
to Metstation records, one for each available variable, and hold monthly data means and
the years from which the data is collected.
Frequently, meteorological stations are at some distance from seed collection or trial
sites. By searching through and matching grid references, the program can select the
nearest station or stations and subsequently retrieve the appropriate data records for a
given site. Alternatively, a Site can be directly related to a Metstation record.

Addresses and mailing
Keeping up-to-date address lists and selecting from these lists is an important aspect of
routine database activity. A large number of names and addresses are stored in the
database including seed recipients, trial participants and other research collaborators.
Names and addresses can be retrieved by country, mailing group or by searching for
surname character matches.
Seed Dispatch records are linked to seed recipients. Individuals may have more than
one address as old addresses are maintained to keep track of historical seed dispatches;
the current address is flagged.
Name and Address records can be linked to address groups for mailing purposes.
Examples of groups include circular letter recipients, participants in a trial series or
members of special research groups. Member records link names to groups and store a
character string concatenating country, surname and initials ensuring the alphabetic
sorting of names within each group. A Mailing History record with a date and reference
text can be stored to log circular letters.

Current developments
Although SISTEM has been in use since 1986, requests for additional data storage and
reporting options are still forthcoming. New data files, programs and menu options are
being added as data management requirements continue to evolve in tandem with
research needs.
The development of the micro computer version of SISTEM has brought about an
increased demand for additional functions related to in situ seed bank, trial and
herbarium management. Several new functions in each of these areas have been singled
out for priority development.
A facility to store digitised maps in the database and to output these with locational
grid data directly to a cartographic package is also being set up. SISTEM holds grid data
for seed collection sites, trial sites, meteorological stations and herbarium specimen
collection sites.
Also planned for inclusion are additional categories of information related to
individual species. Examples are notes on species end uses, conservation status, species
bibliographies, a more detailed treatment of synonymy, an expansion of those fields
describing the natural distribution of a species, a facility to record and group annotated
species check lists for selected geographical areas; and notes on species site
requirements. Many of these facilities will parallel those found in the International
Legume Database and Information Service ILDIS (ILDIS Project Plan, 1986).
Acknowledgements

Ideas for the development and implementation of SISTEM have come from many of the forest genetics and tree improvement research workers based at the OFI and at ESNACIFOR (Escuela Nacional de Ciencias Forestales), Honduras. To all these people I extend my thanks.

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During the past 60 years, perhaps ten million trees from some 215 species have been planted in about thirty projects in Somalia. Names and locations of past and present organisations involved in planting are listed in this study, which finds there has been excessive optimism as to what species, especially exotics, will grow successfully. While it is premature to make firm species recommendations for the different Somali ecological zones, the most promising are identified.


In 1988 the National Hardwoods Programme joined with the Uneven-aged Silviculture Group for a combined meeting, from which some seven papers are presented here. The meeting focussed on three themes: the conversion of broadleaved high forest containing ash, birch, cherry and sycamore as well as beech and oak into productive stands using systems of uneven-aged silviculture; the need for a policy for the expansion of broadleaved forestry; and the need to make the best examples of hardwood silviculture more widely known and available for study.


Seven papers presented at the 1988 BAAS meeting, dealing with trees in support of agriculture; rural policies in the EEC; educating agri-foresters; changing land use in the lowlands; perceptions of the rural landscape; social benefits of planned use; and the harvesting, marketing and production implications of the storm of October 1987.

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THE FOREST ECONOMY OF TIBET

By S. D. RICHARDSON*

SUMMARY
Preparation for a World Food Programme project in Tibet enables a review of the forest resources and economy. The autonomous region is less influenced than ‘China proper’ by new reform policies and suffers from isolation, extreme poverty and an intractable environment. The project involves ‘high tech’, irrigated plantations which at first sight seem inappropriate: but Tibet is served by dedicated foresters, and China’s record in implementing WFP projects is outstanding.

RÉSUMÉ
La préparation pour un projet du Programme Mondial de la Nourriture en Tibet rend possible une revue des ressources et de l’économie forestières. La région autonome est moins influencée que ‘la Chine même’ par la politique nouvelle de réforme et souffre de l’isolement, la misère et un environnement ingrat. Le projet comprend la haute technologie, des plantations irriguées qui à première vue paraissent inaptes: mais le Tibet est servi par des forestiers dédiés, et la conduite de la Chine dans l’execution des projets du Programme Mondial de la Nourriture est excellente.

Introduction
The present day visitor to the Tibet Autonomous Region (TAR) of China comes away with vivid memories of spectacular and grandiose scenery, appalling hygiene and the pervading stench of urine and yak butter in buddhist monasteries. It is a region of contrasts: between the topography of the world’s highest mountains and the steppe grasslands of the northwest; between the conspicuous and unused wealth of the lamaseries and the poverty of village communities; and between the riches of the forest resources and the scarcity of fuelwood. Tibet has the highest urban per capita incomes and the lowest rural household incomes in China: it has the highest birthrate, the highest illiteracy and the highest mortality rate — but also the highest social security expenditure. Less than 50% of China’s Tibetans live in Tibet: the more affluent live to the east and north of the TAR. Except for the conspicuous religious presence the Tibetan plateau closely resembles Outer Mongolia; both have long pre-industrial feudal histories and, in rural areas, support similar lifestyles.

The natural forests represent 15.5% of China’s total growing stock; yet their annual timber production is only 0.3% of the harvest. Recent events in Tibet — in particular, the beginning of a World Food Programme (WFP) assisted development project, with a significant plantation forestry component, have aroused professional interest in a little known and traditionally mysterious part of the world.

* (P.O. Box 47, Motueka, New Zealand)
The Forest Resource

The 1.25 M km² of Tibet divide naturally into three regions — the northern plateau which covers over half the area; the outer plateau which supports agricultural development (including the Lhasa Valley) and some remnants of natural forests; and the south-eastern plateau or "River Gorge Country" of less than one tenth of the area of the region but rich in natural forests. (Here, the earth’s deepest river valleys — of the Yangtze, the Mekong and the Salween — run within 50 miles of each other.)

The northern coniferous forests of east Tibet comprise many species of Picea and Abies, with occasional admixtures of Larix (L. potanini and L. griffithii) and Tsuga (T. chinenis, T. yunnanensis and T. dumosa). The Picea-Abies mixture is not a simple one and includes ten species of Abies. One Chinese botanist has identified 80 formations and 250 forest types! The forests are over-mature, carrying some 3-400 m³ per ha of large trees. Where they are accessible they are being exploited and the forest cover has reduced from 20% in the 1950’s to less than 10% at present (Richardson, 1987). Regeneration after clearfelling is difficult because of the high diurnal temperature changes (up to 278C.) and high soil surface temperatures. Natural generation is damaged by excessive heat and planted seedlings die from frost-heave. Managed as they are, these forests are a non-renewable resource.

The Picea-Abies forest reaches its climax on north facing slopes above 3,500 m. Below, several species of pine (Pinus tabulaeformis var. densata, P. armandi, and P. yunnanensis) and Acer-Betula forest occur sandwiched between the montane coniferous forest and the evergreen broadleaved forest at lower elevations (in Sichuan and Yunnan). Above the timber line (ca 4,000 m.) Rhododendron species form a transition to alpine scrub and meadow plants. The ground vegetation in the forests is sparse and the forest floor comprises only mosses and shade-bearing shrubs (Berberis, Ribes, Cotoneaster, etc). Descriptions of the environment, natural vegetation and land use are contained in Ren Mei’e et al. (1985).

South facing slopes are often characterised by evergreen oaks and junipers including, in the north-east, the dwarf species Juniperus lemeana, J. przewalskii, J. saidamensis, J. formosana and J. tibetica. The wood of juniper is sacred and hearths for burning it are found near many temples; the fragrant smoke constitutes an offering and bestows blessings. Needless to say, it is becoming increasingly scarce.

The Tibetan plateau is of little importance in Chinese forestry but, because of its size, it has a major effect on climate. In the southeast, below the montane coniferous forests, there are evergreen broadleaved species (Tilia spp., Magnolia spp, and Quercus spp.) in the lower valleys. The coniferous zone comprises Abies webbian, Picea likiangensis, Larix griffithii and Picea spinulosa, with Tsuga dumosa at lower elevations. Along water courses, species of Juniperus, Salix, Ulmus, Populus and Hippophae occur, with — in the semi-desert — a shrub flora of Berberis spp., Sophora moorcroftiana, Caragana
tibetica, C. jubata, Salix biondiana, Potentilla fruticosa, Rosa species etc. It is from these groups that plantation species may be selected, whether for timber, fuelwood or multi-purposes. The meadow soils support Kobresia, Carex, Eriophorum, Helictotrichon, Deschampsia and Poa spp., among the cosmopolitan variety of herbs and shrubs.

The fauna of much of Tibet is characteristic of deserts and steppes. There are several hoofed species, well adapted to harsh conditions which require them to migrate long distances in search of food — notably the yak, the wild ass and the Tibetan antelope. The most numerous mammals, however, are rodents, notably marmots, which feed a range of predator from bears to leopards. The fauna, indeed, is essentially similar to that of Outer Mongolia (Richardson, 1987a).

Table 1
Forestry and Related Statistics of Tibet — 1986/7

<table>
<thead>
<tr>
<th>Total land area (ha.)</th>
<th>125,000,000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area of Forest Land</strong> (ha.)</td>
<td><strong>6,323,000</strong> (1973)</td>
</tr>
<tr>
<td>Area of Timber Forests</td>
<td>5,160,000 (1977)</td>
</tr>
<tr>
<td>Area of Protection Forests</td>
<td>385,000</td>
</tr>
<tr>
<td>Area of Fuelwood Forests</td>
<td>766,000</td>
</tr>
<tr>
<td>Area of Economic Forests</td>
<td>12,320</td>
</tr>
<tr>
<td>Of which, Fruit</td>
<td>4,800</td>
</tr>
<tr>
<td>Walnut</td>
<td>7,300</td>
</tr>
<tr>
<td>Tea</td>
<td>200</td>
</tr>
<tr>
<td>Area of Nurseries</td>
<td>1,267</td>
</tr>
<tr>
<td><strong>Area of New Plantation</strong></td>
<td><strong>18,667</strong>* (1987)</td>
</tr>
<tr>
<td><strong>Area of Wasteland</strong> (plantable)</td>
<td><strong>1,000,000</strong></td>
</tr>
<tr>
<td><strong>Area of Non-forest Land</strong></td>
<td><strong>117,700,000</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Forest Production (000 m³)</th>
<th>1984</th>
<th>1985</th>
<th>1986</th>
<th>1987</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logs (State Plan)</td>
<td>290</td>
<td>209</td>
<td>183</td>
<td>197</td>
</tr>
<tr>
<td>of which, exported</td>
<td>(44)</td>
<td>(30)</td>
<td>(27)</td>
<td>(30)</td>
</tr>
<tr>
<td>Domestic</td>
<td>(246)</td>
<td>(179)</td>
<td>(156)</td>
<td>(167)</td>
</tr>
<tr>
<td>Logs, Private</td>
<td>105</td>
<td>107</td>
<td>70</td>
<td>125</td>
</tr>
<tr>
<td>Sawn wood</td>
<td>n.a.</td>
<td>130</td>
<td>240</td>
<td>175</td>
</tr>
<tr>
<td>Fuelwood</td>
<td>n.a.</td>
<td>380</td>
<td>400</td>
<td>350</td>
</tr>
<tr>
<td>Walnuts (tonnes, in shell)</td>
<td>n.a.</td>
<td>n.a.</td>
<td>2,000</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

Growing Stock, 1984, = 1,436 mill. m³ (unchanged from 1973)

* Excluding line paintings

Sources: T.A.R. Forestry Bureau Lhasa; MOF, Beijing
Timber Production and Consumption

In most of Tibet there is a subsistence forest economy and there are no records of timber production or consumption. Only industrial production under the State Plan is effectively recorded; legal production outside the Plan is known to the extent that its consumption is recorded — but that accounts for a fraction of non-Plan log production. Most of the non-Plan production is now sold on free markets and volume estimates are not reliable.

Production under the State Plan is indicated in Table 1. Log production is around 300,000 m$^3$ entirely from the southeast of the Autonomous Region, and comprising mainly over-mature logs of *Abies*, *Picea* and *Pinus*. Logs destined for conversion in Tibet are allocated with a concessionary stumpage of less than one-sixth of that relating to exports; some 20–50,000 m$^3$ is exported through Sichuan and Yunnan.

Most State Plan timber produced in Tibet is channelled through the provincial capital, Lhasa. Official statistics record only 150,000 m$^3$ of sawn wood plus some 30,000 m$^3$ imported as lumber and provide no measure of consumption. Estimates of production outside the Plan are, inevitably, more conjectural than for many other provinces of China. The Cotchell Report (Richardson, 1987) discusses estimates for the whole of China and concludes that non-Plan production of logs is roughly the same as Plan production. There are reasons for believing that in Tibet, non-Plan production significantly exceeds Plan production though most of it is exported. In the major accessible logging areas of the east, the rivers flow southeast and south and log transport is by water. Other than on official construction projects (most of which receive sawnwood allocations), most logs sold in Lhasa have been axe-felled, a sure sign that they have probably been felled illegally.

Fuelwood consumption is impossible to estimate with accuracy but the demand for firewood in Tibet is greater than in many provinces because there is no coal or oil production. Moreover, the sparsely covered hills are — near settlements — being denuded of what little scrub cover they support for fuel. It is perhaps the most important feature of the forest economy. Using an F.A.O. derived parameter for household fuel consumption, the volume of demand in Tibet would approach 1.5 M m$^3$. In fact, in rural areas most fuel derives from scrub, branches and agricultural residues (including dung); but if conservation farming is practised, the scrub and dung components will have to be replaced in part by plantation grown materials. The magnitude of Tibet’s need is exemplified by prices paid in Lhasa free market for domestic fuelwood; the price of 1 m$^3$ exceeds the average annual *per capita* income in the Lhasa Valley. Fuelwood is trucked into the capital from a distance of 600 km.

Forest Policy and Institutions

The Tibetan Autonomous Region Forestry Bureau articulates five points of regional policy:

1. To regenerate the natural forests;
2. To work towards self sufficiency in construction timber and fuelwood and to balance demand by supply;
3. To create protection forests against sand movement and to protect communities;
4. To control detrimental land use on steep slopes, including grazing and fuelwood gathering;
5. To protect wild life resources, create nature reserves and observe “correct” ecological principles.
In addition, the Bureau endeavours to implement some national policies, particularly devolution. The extent of autonomy, however, is undefined and, as in other countries, can lead to uncertainty regarding the respective responsibilities of the Centre and the Regions. For example, the “Baogan Daohu” contract responsibility system which is so prominent a feature of the new “Reform” policies in China has been implemented in Tibet to a much more limited extent. Only 40,000 ha in total has been contracted for forestry, most of it former commune land. Problems arise from intractible sites and the poverty of farmers; and contracts are only verbal, since most Tibetan household heads do not read Chinese. Throughout China, the contract system has led to devolution of decision-making with respect to species selection and management systems, job specialisation and work scheduling; and to de facto tenant farming under secure land holding. In Tibet, it is reported to have been introduced successfully in horticulture and agriculture, but is relatively untried in production forestry. Specialised households operate sawmills, log and fuelwood transport and sales, and some forest nurseries. Contracts are also in place for particular operations (e.g. seed collection, ground preparation, planting, etc.) but there are no contracts covering overall forest management (as there are in farming) — other than for orchards. It remains government policy to introduce the total responsibility concept whenever possible. Clarke (1987) observes that in the economic history of Tibet there has always been a time-lag between the implementation of policies in “inner China” and in Tibet.

The organisation of forestry in the region is also different from that in most provinces in China and has been subject to recent change. The regional government is advised with respect to forestry by a Commission on Agriculture, Animal Husbandry and Forestry. Forestry only became a part of it in 1987 — in recognition of the need for integration; the separate bureaux (at municipality and county level) have yet to adjust to this need. Apart from the Commission, regional bodies which affect forestry are the T.A.R. Planning Commission (which controls the Material Allocations Bureau) and the Department of Electric Power and Industry which controls activities (e.g. pulp and paper, match manufacture) which in other provinces of China come under the Ministry of Light Industry. (This is perhaps academic; there is only one pulp and paper mill — which is not operating — and one match factory, which fails to meet national safety standards.) But more important is the control by the Commission of activities formerly the responsibility of the Regional Timber Corporation — a forestry resources inventory team, a moribund research institute and a nursery. Thus the Forestry Bureau overseas activities at prefecture (six) and municipalities (1), and at county levels. Activities include nurseries (one in each county — of which there are 77 in the TAR), protection stations (concerned with fire protection and monitoring disease and illegal felling — and of which there are thirty) and checking stations which monitor timber transport and are primarily concerned to detect illegal movement of wood. The Forest Research Institute has little impact (according to one informant, it is “an iron rice bowl” and the principal activity of the researchers is “eating”!). Similarly, despite the existence of the forest resources inventory team, the official resource statistics have not changed since 1973. Throughout China there is officially a five-yearly update of forest resource data but in some provinces (including Tibet and — perhaps more importantly — Yunnan) they have not changed for 15 years.

The inadequacy of data bases for forestry planning (perhaps inevitable in view of the relatively short time that forestry has been practised in Tibet) gives cause for concern. Because it is small, the forest economy is easily distorted. There are hidden subsidies in the multiple pricing system (apart from differential stumpages according to the destination of logs, prices vary with end-user as well as end use). There are no measurements (as distinct from estimates) of tree growth and yield, or of labour norms.
Social and economic statistics are of varying reliability and there are no established procedures for monitoring and recording forestry practices and results. Perhaps because of the death of planning information, there is a tendency to place excessive faith in what data are available; to accept statistics too readily; and to extrapolate from them beyond the limits of applicability. The availability of electronic calculators leads to the appearance of a precision which is an illusion. And the acceptance of unchanging statistics for natural forest areas, may be dangerously misleading. Thus, in the Lhasa Valley, hill forest areas are quoted to the nearest hectare; in the absence of aerial photography, such estimates are mythical, and their acceptance can lead to a complacency with respect to fuelwood availability which is totally unjustified. A unique culture and language are part of Tibet’s strength: but they can also erect barriers to the transfer of technology. Forestry projects in the TAR must, therefore, place particular importance on training, extension and demonstration.

The Selection of Species

The essence of the WFP-assisted Project in Tibet is irrigation; and it is based on the fact that in the Lhasa River valley there are under-utilised resources of land, water and people. Forestry inputs serve to underpin the agriculture components, through the provision of shelterbelts (to mitigate the high winds that sweep through the valleys of the River and its tributaries), stream and canal bank stabilisation, and sand fixation. At the same time there is an urgent need in valley communities — and particularly in Lhasa City — for fuelwood, wood for farm and household implements, as well as more conventional construction timber and roundwood. At present industrial timber comes into Lhasa from Nyinghe — a distance of 500 km by road — and there are no railways in the province. (The nearest railhead is at Golmud, 1,000 km from Lhasa in Qinghai.)

There is only a brief history of plantation forestry in Tibet and it is restricted to the flood plains of the rivers. The conventional timber species are *Populus* spp. but walnut and willow have been grown, while nitrogen fixing trees (*Hippophae rhamnoides*, *H. tibetica*, *Sophora moorcroftiana*, *Amorpha fruticosa*) have also been planted. The favoured species are the so-called *Populus pekinica* (in fact a hybrid between *P. pyramidalis* and *P. cathayana*), together with *P. alba*, *P. szechuanica* and *P. rotundifolia* var. *duclouxiana*. The last three species are indigenous and are used where irrigation is less than certain. Rotations vary from 25–30 years. All species coppice but under a coppice system *P. alba* yields a higher total volume than the others. Moreover, its stem form is better and in a situation where there is a demand for small roundwood in many end uses (house poles, roofing members, implements *etc.*) there are advantages in optimising rather than maximising yields.
The willows have particular roles to play in canal bank stabilisation, sand fixation and as fuelwood. The main species are *Salix viminalis*, *S. babylonica*, *S. alba* and *S. purpurea*. The first is of particular value in canal bank stabilisation and provides osiers for the baskets commonly used in the valley communities. It is a more versatile species than the others but it is also palatable to stock. *S. purpurea* is not much planted in Tibet but it grows naturally in the hills and is less dependent on assured water than the others. *S. babylonica* is more water demanding but grows on saline sands of high pH and makes a good windbreak species. It can be pollarded to provide overhead shelter and to enable multiple stems to grow unhindered by browsing. Finally *S. alba* is the preferred species — with similar properties to *S. babylonica*, but slightly faster growth and a reputation for greater versatility with respect to end use. It is favoured for tool handles and turnery.

Two other willow species grow in the hills above the valley — *S. suchowensis* and *S. myrtillaceae*. The latter is harvested for osiers. The multiple-purpose species growing in the Lhasa Valley are used — apart from fuelwood — mainly for fruit, medicine and as fodder. *Hippophae tibetica* survives on dry sites without irrigation and can be used in sand fixation. It coppices and (if protected from grazing) will also regenerate from root suckers. The stems, if allowed to grow to suitable size, are used for roof poles, tool handles and to make traditional butter churns. It forms a very hard wood with a high calorific value. *Rosa* and *Caragana* grow in the hills; both are resistant to browsing (they carry thorns) and both are hardy. *Rosa* provides fruits — rich in vitamin C — and the sweet flowers of *Caragana* are steamed with highland barley to give an edible mash. Together with *Sophora* they can be direct seeded (the latter after treatment with boiling water) and are nitrogen fixers. Other species found in the valley along water courses include *Ulmus pumila* (which is in demand as a decorative carving timber and for the manufacture of bobbins) and walnut which has long been grown around monasteries for both fruits and timber.

A wide variety of species has been established in and around Lhasa by the Highways Bureau of the Ministry of Transport and the Bureau of Parks and Gardens. A list is presented in Table 2. Many of them have not been successful — they are either too slow growing or frost-tender. Production costs in nurseries are very high compared with either the Bureau of Forestry or the People's Liberation Army (PLA) nurseries (the latter, as well as PLA plantations, are very well tended and demonstrate the best management practices seen anywhere in China).

Seen in spring, the Forestry Bureau plantations appear healthy and growing well. Some insect pests on poplars have been reported (notably a stem rust, *Dothiorella gregaria*, a leaf-eating caterpillar, *Cerura menciana*, and an insect pest in nurseries, *Leptomias longesetosus*), but appear not to be serious. Because of the short tradition of artificial plantations in Tibet, however, it seems important to keep silviculture and management as simple as possible and not to depart too far from tried practices. It is
### Table 2
Catalogue of Trees Planted in Lhasa City, 1987

#### I. Indigenous Species

1. Coniferous
   - *Pinus densata*
   - *P. griffithii*
   - *Picea asperata*
   - *Platycladus orientalis*
   - *Sabina (Cupressus) squamosa*

2. Deciduous
   - *Ulmus pumila*
   - *Salix paraplesia*
   - *S. microstachyoides*
   - *S. matsudana var. tortuosa*
   - *Hippophae rhamnoides*
   - *Populus alba*
   - *P. nigra var. italica*
   - *P. szechuanica var. tibetica*
   - *Prunus persica*
   - *Malus baccata*

#### II. Introductions

1. Coniferous
   - *Pinus tabulaeformis*
   - *P. thunbergii*
   - *Cedrus deodara*
   - *Juniperus rigida*
   - *Platycladus orientalis*
   - *Sabina chinensis*
   - *S. chinesis cv. “Kaizuca”*

2. Deciduous
   - *Robinia pseudo-acacia*
   - *Sophora japonica*
   - *Morus alba*
   - *Fraxinus chinensis*
   - *Pyrus xerophylla*
   - *Prunus salicina*
   - *Malus pumila*

tempting to take advantage of the rare opportunity — in China — to irrigate timber trees by prescribing a wider range of higher value, more demanding species. The need, however, is not for high value species but for low-cost firewood and utility round-wood: it would be unwise to venture beyond species known to grow in the Project area.

Some present practices could be improved. Many visitors to China remark on her silvicultural conservatism — plantation spacings are ultra close; thinnings are carried out reluctantly and very lightly; culling in nurseries is inadequate. On the other hand pruning is both reckless and excessive. Such practices — especially when applied to poplars — ignore the proven benefits of wider spacings. Nursery practice leaves something to be desired. Of the principal species only *Hippophae spp.* are raised from seed — with a reported 50% germination, and seedlings remaining in the nursery for two years. Poplar cuttings and sometimes willow are struck in the nurseries about 10 cm apart (at a density of 90,000 per ha). They are grown for as much as three years with no root pruning or thinning and planted out when 2–3 m tall. There is no systematic use of fertiliser but, if it is available, animal dung and a nitrogenous chemical fertiliser are applied.

A cause of some concern is the probable narrow genetic base of the main species, especially *Populus pekinica*. It was introduced to Tibet in the late 1960’s and probably derives from a single clone. Such “high-tech” forestry may be over ambitious for Tibet and, for this reason, indigenous species are being included even though they show slower growth rates.
Establishment involves rough levelling and the construction of channels (for irrigation) in which saplings are set 2 m apart. Because it appears impossible to exclude grazing animals, fencing is always deemed necessary despite the very high cost (all materials must be imported). Given the high demand for small roundwood products (fuelwood, stakes, posts and roof poles) of all species, it should be financially feasible to thin from shelter belts regularly at three-yearly intervals, thus accommodating Chinese foresters’ reluctance to thin heavily. With canal bank planting there is a problem in deciding on the need for fencing. Unless belts are several rows wide, fencing is economically questionable; but planting several rows of trees along the canal banks reduces the availability of agricultural land. Ideally, bank planting should not require fencing and it may be that, if trees are given under contract responsibility to the adjoining land owner, he will protect them from browsing.

Alternatively, a joint contract with the land holder and his village may provide sanctions to control damage. Technically, the use of solar-powered electric fencing would be feasible; again, it may be too ambitious for Tibet.

Apart from conservatism, the greatest constraint upon forest management in Tibet (again, as in most of China) is the reluctance of cadres to seek advice from outside their particular hierarchy. The WFP-assisted Project in the Lhasa Valley is (inevitably) to some extent experimental: advice on arid zone multiple purpose species and their management could be obtained from the Desert Research Station at Lanzhou (which is part of the Chinese Academy of Sciences). There is expertise in arid zone forestry in Liaoning Province. The bureaucracy, however, is characterised by a combination of Soviet-type vertical controls and “horizontal cleavages” (Wong, 1986) resulting in fragmentation of administration and reluctance to seek advice from outside. The WFP-assisted project involves several Bureaux of the Autonomous Region (Water Conservation, Agriculture, Forestry, Grain, Finance and Planning) and inter-disciplinary project offices at municipality and county levels will need to co-operate closely if it is to be successful. The new Reform policies are intended to enable and enforce the integration of disciplines and inter-departmental co-ordination of this kind.
Conclusion

The abolition of the communes in China has no doubt generally increased economic efficiency; but it has left some gaps which have yet to be filled by collectives and the contract responsibility systems which, in most provinces, have replaced them. The commune provided a means of mobilising the masses for campaigns in public services — including tree planting, soil conservation, litter collection and education. Several of the sub-components of the WFP-assisted Project in Tibet are indeed designed to rehabilitate communal irrigation systems which collapsed when the communes ceased to be. And there are many miles of roadside tree planting in the Lhasa valley, expensively and meticulously protected from animals by brick stockades, now abandoned. Nor is it certain that the new market-driven economy gives enough incentive for conservation grazing practices. Clarke (1987) poses the question of whether it may not be “rational” for pastoralists to maximise their immediate returns and that “the creation of markets may serve quite literally to clear the ground in a tragedy of the commons scenario”.

There are some grounds for optimism. Rural Tibet is a long way yet from being market driven, and the writ of Beijing does not run strongly. There is recognition that central economic policies may be inappropriate in Tibet: and there are tax holidays, concessional food prices, heavily subsidised goods and services, and acknowledgement of the need for the support of local people in setting policies. Most importantly, Tibet is served by a cadre of dedicated foresters — they speak Tibetan and some have worked for two decades in an environment without amenities and in extremes of climate. They lack breadth of training (the Cultural Revolution effectively suspended it for a crucial decade) and they tend to be conservative: but there can be no doubts about their sincerity and enthusiasm. WFP projects are not run by “international” staff and make little use of consultants; the responsibility for implementation rests entirely with the national authority. Of “food for work” projects in forestry, the majority have over-fulfilled their targets. China’s large and under-employed workforce and history of mass mobilization of labour for rural development is perhaps one reason for their success.

Acknowledgement

For the opportunity to visit the Tibetan Autonomous Region, I shall always be grateful to WFP and FAO; and, in Tibet, particularly to Liu Zong De — stalwart veteran of many a professional argument which distracted the mind from the discomforts of ill-sprung vehicles (mechanical and animal) and of socialist plumbing.

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DIEBACK DISORDER IN PINUS PATULA, P. ELLIOTTII AND P. CARIBAEA AT SAO HILL, SOUTHERN TANZANIA

By J. L. TANGWA, S. A. O. CHAMSHAMA and V. R. NSOLOMO*

SUMMARY

This study was carried out at Sao Hill Forest Project, Southern Tanzania, to determine the extent and effects of dieback on growth of Pinus patula, P. caribaea and P. elliottii of ages between 5 and 11 years old. 41 plots of size 0.04 ha were sampled to determine the impact of dieback on height growth and its distribution in relation to stocking, age of stands and catenary position.

Results showed that there was statistically significant differences in heights between dieback affected and non-affected trees. It was also found that young stands were mostly affected in height growth and that P. patula was more attacked than the other two species.

Mean height to the point of infection (deformation) was 4.0 m, a length which can be utilized by the Sao Hill sawmill and the Southern Pulp and Paper mill.

Dieback distribution was neither related to stocking nor age of stands. Distribution of the disease was found to be related to the position of stands along the catena.

RESUMEN

El estudio se llevo a cabo en el Proyecto Forestal de Sao Hill al sur de Tanzania, con el fin de determinar la amplitud y efectos de la muerte regresiva (del apice hacia abajo) sobre el crecimiento de Pinus caribaea; P. patula and P. elliottii de edades entre los 5 y 11 anos. 41 parcelas de 0.04 Ha fueron muestradas para determinar el impacto de dicha enfermedad sobre el crecimiento en altura y su distribucion con relacion a la densidad, edal del rodal y posicion en cadena. El analisis estadistico mostro diferencias significativas en altura entre arboles afectados por la muerte regresiva y los no afectados. Tambien se encontro que los rodales mas jovenes fueron mayormente afectados en altura y que la influencia de la enfermedad se manifesto principalmente en P. patula, siendo menor en las otras dos especies. La altura media del punto de inceccion (deformacion), fue de 4.0 m, longitud que puede ser utilizada por el Aserradero de Sao Hill y la Fabrica de Pulpa y Papel del Sur. La distribucion de la muerte regresiva no se asoció con la densidad ni la edad de los rodales. Se encontro que dicha distribucion esta relacionada con la posicion de los rodales a lo largo de la cadena.

Introduction

Large scale planting of exotics in Tanzania started around 1950. It was then realized that the dwindling indigenous hardwoods alone would not meet the country's future timber requirements. At present the area under exotic forest trees in Tanzania is about 78,900

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ha (Forest Division 1986). About 88% of the total area is covered by softwoods (Pinus patula, P. elliottii, P. caribaea and Cupressus lusitanica) and the rest by hardwoods (Tectona grandis and some Eucalyptus spp.)

Sao Hill, with about 38,000 ha planted (93% softwoods) is the largest forest project in Tanzania. The main species planted are Pinus patula, P. elliottii, P. caribaea, Cupressus lusitanica and some Eucalyptus spp.

Sao Hill timber is utilized by a nearby sawmill which uses about 45,000 m³ of logs annually and a pulp and paper mill (some 60 km away) which uses 300,000 m³ of round wood annually.

The performance of the tree species at Sao Hill is quite variable. On high quality sites, P. patula for example produces about 600 m³ of wood per hectare at rotation age (25 years) with mean annual increment of about 25 m³ per ha. In certain locations, the performance of P. patula, P. elliottii and P. caribaea has been observed to be unsatisfactory. Procter (1967) noted that the main problem was dieback, a condition in which a gradual dieback starts with the tip, advancing slowly down the stem. Causes of the disease at Sao Hill have been described by Procter (1967), Waring (1982) and Canon (1985) as being boron deficiency, drought stress and possibly inadequate land preparation before planting. Another cause of dieback reported on pines in Tanzania (but not verified at Sao Hill) is due to fungal infection by Diplodia pinea and D. natalensis (Howland and Gibson 1969, Wormald 1975). The consequence of this disease has been reduced survival and growth and stem deformation.

Although the dieback disorder at Sao Hill was observed nearly 20 years ago, its extent and effect on growth has not been established. This study aimed at providing such information.

**Materials and Methods**

**Survey area**
The study was conducted at Sao Hill Forest Project, Southern Tanzania (8°18’S, 35°6’E). Altitude ranges between 1700 and 2000 m above sea level. The area is generally rolling with low hills and wide flat bottomed valleys. Sao Hill receives between 600 and 1500 mm of rainfall annually, mostly during a single rain season which lasts from November to April. Temperatures are fairly cool, the mean monthly minima and maxima temperatures are 10°C and 23°C respectively. Soils are kaolinitic with low base exchange capacity.

**Data collection**
A total of 41 circular plots of size 0.04 ha each were sampled in thinned and unthinned stands aged between 5 and 11 years. Eight of these were permanent sample plots (established for growth monitoring) and 33 were temporary plots randomly selected along the catena. Distance between plots ranged from 400 m to 1000 m. Dieback affected trees were regarded as those with either dead leading shoots or dead portions of the leading shoots or those with living but curled shoots (Procter 1967, Canon 1985). Frequency of the disorder on trees was graded as affected and non-affected.

All trees in a plot were measured for diameter at breast height (dbh) and two trees, one with and another without dieback and of the same diameter were regarded as a pair and measured for total height. Height to the point of deformation was measured on randomly selected infected trees.
Along the catena, dieback occurrence was noted in relation to its position, that is, whether it was found at the bottom (valley/depression) middle or at the top of the terrain.

**Data analysis**

Total tree height measurements for the pairs comprising of affected and non-affected trees were subjected to a t-test (paired sample formula) and the differences compared at 0.01 and 0.001 levels of probability. For dieback affected trees mean total heights and mean heights to points of infection were determined.

Trees with dieback for each species were represented as a percentage of all trees in a hectare. The relationship between dieback intensity, age and stocking was also determined.

For the same species and age, dieback frequency was averaged according to catenary position (*i.e.* bottom, middle or top).

**Results and Discussion**

*Height differences between dieback affected and non-affected trees*

Height differences between dieback affected and non-affected trees were significant for *P. patula* and *P. caribaea* and non-significant for *P. elliottii* (Table 2). Where differences were significant, the mean heights of non-affected trees were higher than those of affected trees. The detrimental effects of dieback on growth increment have been observed elsewhere (Savory 1962, Singh 1982 and Kramer 1986). However, dieback affected trees may not stop growing because the adventitious shoots formed after the attack can continue to grow at the same rate as the original leading shoots. This may explain why some affected trees tend to be equal or more in height to normal trees and hence contributing to bringing insignificant height differences.

The mean heights to the points of deformation do not show any consistence with the age or the total height of the affected trees (Table 1). This means deformation occurs

**Table 1**

Height comparison between dieback affected and non-affected *P. patula, P. caribaea* and *P. elliottii* trees at Sao Hill, Southern Tanzania.

<table>
<thead>
<tr>
<th>Age</th>
<th><em>P. patula</em></th>
<th><em>P. caribaea</em></th>
<th><em>P. elliottii</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>7.3</td>
<td>5.3</td>
<td>4.3</td>
</tr>
<tr>
<td>7</td>
<td>9.1</td>
<td>6.3</td>
<td>5.3</td>
</tr>
<tr>
<td>8</td>
<td>11.8</td>
<td>9.5</td>
<td>4.3</td>
</tr>
<tr>
<td>19</td>
<td>13.9</td>
<td>8.1</td>
<td>3.4</td>
</tr>
<tr>
<td>11</td>
<td>15.5</td>
<td>13.5</td>
<td>12.6</td>
</tr>
</tbody>
</table>

Mean height of normal trees (m)

<table>
<thead>
<tr>
<th>Mean height of affected trees (m)</th>
<th>5.7</th>
<th>7.3</th>
<th>10.7</th>
<th>12.7</th>
<th>13.5</th>
<th>4.3</th>
<th>5.3</th>
<th>8.1</th>
<th>3.4</th>
<th>12.6</th>
</tr>
</thead>
</table>

Number of pairs

<table>
<thead>
<tr>
<th>Number of pairs</th>
<th>29</th>
<th>29</th>
<th>29</th>
<th>30</th>
<th>30</th>
<th>27</th>
<th>29</th>
<th>29</th>
<th>4</th>
<th>15</th>
</tr>
</thead>
</table>

Mean height of point of deformation

<table>
<thead>
<tr>
<th>Mean height of point of deformation</th>
<th>4.6</th>
<th>5.3</th>
<th>4.8</th>
<th>4.1</th>
<th>2.5</th>
<th>5.6</th>
</tr>
</thead>
</table>

**=Significant at P<0.01
***=Significant at P<0.001
NS=Not significant
arbitrarily at different points of the stem or shoot of the growing tree.

The number of times a tree is infected will determine the quality and size of utilizable logs or poles to be salvaged from an infected tree as observed by Savory (1962) and Kramer (1986). Canon (1985) noted that defects resulting from dieback have also adverse impact on pulpwood production.

The average log length for both the Sao Hill sawmill and the pulp and paper mill is 4 m which means one can only get a single log from an infected tree at Sao Hill plantations.

As observed by Wormald (1975), height to the point of infection also demarcates the position of the zone of weakness at which a tree becomes susceptible to wind breaks in later years.

Dieback intensity

The overall results show that dieback affected trees per hectare averaged 30% for *P. patula*, 18% for *P. caribaea* and 17% for *P. elliottii* (Figures 1 and 2). Figures 1 and 2 show that the number of trees affected by dieback per hectare for the three species was randomly distributed and did not show any regular relationship with stocking or age of the studied stands.

Contrary to the findings of this study, Canon (1985) mentioned poor stocking as one of the factors which influence dieback at Sao Hill.

The high intensity of dieback on *P. patula* may be attributed to the vulnerability of its genotype (Canon 1985) and its sensitivity to extended periods of drought (Gibson 1970).

![Figure 1](image_url)

**Figure 1.** Relationship between dieback of *P. patula*, *P. caribaea* and *P. elliottii* with stocking at Sao Hill, Southern Tanzania.
DIEBACK OF PINES IN TANZANIA

The earliest time of start of dieback at Sao Hill has been observed to be at the end of the first and more often the second dry season, that is 11–23 months after planting (Procter 1967).

Dieback distribution along the catena

Dieback distribution along the catena is shown in Table 2. The table shows that dieback intensity for *P. caribaea* and *P. elliottii* was higher at the bottom and top and lower in the middle. For *P. patula* the intensity increased as one ascended from bottom to top of the catena.

Table 2

Average dieback distribution (%) of *P. patula*, *P. caribaea* and *P. elliottii* at Sao Hill, Southern Tanzania.

<table>
<thead>
<tr>
<th>Species</th>
<th>Position along the catena</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bottom</td>
</tr>
<tr>
<td><em>P. patula</em></td>
<td>13</td>
</tr>
<tr>
<td><em>P. caribaea</em></td>
<td>19</td>
</tr>
<tr>
<td><em>P. elliottii</em></td>
<td>24</td>
</tr>
</tbody>
</table>
The inconsistent variation of dieback with catena among the three species is noteworthy. The distribution of dieback at Sao Hill has been attributed to both soil physical and chemical characteristics. Procter (1967) found that dieback was induced by boron deficiency as exemplified by foliar analysis (14 ppm of boron in healthy trees and 3 ppm in affected trees). Waring (1982) noted that under drought stress boron becomes deficient. Canon (1985) further attributed dieback incidences at Sao Hill to inadequate land preparation before planting.

**Conclusions**

The results from this study are in agreement with the widely accepted conditions on the effects of dieback on forest trees.

Dieback at Sao Hill significantly affects height growth of *P. patula* (ages 5–11 years) and *P. caribaea* (ages 5–9 years) but not of *P. elliottii*. The spread of the disease was much less in stands of *P. caribaea* than in the other two species.

Dieback has effects on the quality and size of logs and the number of utilizable logs that can be obtained from an affected tree.

The distribution of dieback intensity has no clear relationship with stocking or age of the stands, but has been found to vary on different positions along the catena.

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THE FOREST AT WALLINGS RESERVOIR, ANTIGUA WEST INDIES, 44 YEARS AFTER J. S. BEARD'S STUDY: CONJECTURE ON THE PATTERNS OF CHANGE

By R. MACKLER and P. HANNAH

SUMMARY

Antigua is a Caribbean island that was almost entirely deforested during the 1600's for establishment of a sugar industry. With the decline of this industry a mixture of natural and introduced vegetation has succeeded onto abandoned agricultural lands. Inventory of one 0.2 ha (0.5 acre) quadrat at the Wallings Reservoir Forest Reserve in southwestern Antigua by J. S. Beard (Colonial Forest Service) in 1944 documented a young pole forest 15.2 to 21.3 m tall. This forest had a basal area of 22.8 m² per ha, a quadratic mean diameter of 20.6 cm and 20 tree species. A resurvey of the same vicinity in 1988 indicates that the stand has a canopy height of 9.0 to 11.0 m, with a basal area of 19.8 m² per ha (trees 10 cm dbh and greater), a quadratic mean diameter of 19.3 cm, and 26 tree species; ten of these species are evidently new to the stand. Candlewood (Guettarda scabra), a pioneer species, is now the most common tree, while Spanish oak (Inga laurina) was most common in 1944. The changes in composition are being strongly influenced by “selective” harvesting of preferred species. It appears development towards a late successional forest is being held in check by this activity.

RESUME

L'Antigua est une île des Caraïbes qui était presque entièrement déboisée pendant le dix-septième siècle pour établir une industrie sucrière. Avec le déclin de cette industrie, un mélange de végétation naturelle et introduite a succédé sur des friches. L'inventaire d'un quadrat de 0.2 ha (0.5 acre) à la Réserve Forestière de Wallings reservoir au sud-ouest de l'Antigua par J. S. Beard (Service Colonial des Forêts) en 1944 documentait une jeune forêt de poles de 15.2 à 21.3 m de hauteur. Cette forêt avait une surface terrière de 22.8 m² par ha, un diamètre moyen quadratique de 20.6 cm et 20 essences forestières. Un reinventaire du même endroit en 1988 montre que le peuplement a une hauteur de couvert de 9.0 à 11.0 m, avec une surface terrière de 19.8 m² par ha (arbres avec un diamètre à hauteur d'homme de 10 cm et plus), un diamètre moyen quadratique de 19.3 cm, et 26 essences forestières; dix de ces essences sont évidemment toutes nouvelles pour le peuplement. Guettarda scabra, une essence pionnière, est maintenant l'arbre le plus fréquent, tandis qu'Inga laurina était le plus fréquent en 1944. Les changements du mélange sont fortement influencés par la récolte 'sélécive' d'essences préférées. Il paraît que le développement vers une forêt de fin de succession est freiné par cette activité.

RESUMEN

La isla caribeña de Antigua fue casi enteramente deforeestado durante los años de 1600 para el establecimiento de la industria azucarera. Con el decaimiento de esta

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industria, una mezcla de vegetación natural e introducida se estableció sobre las tierras que se utilizaron para la actividad agrícola. En el año de 1944, se realizó un inventario de cuadrantes de 0.2 ha. (0.5 acres) en la Reserva Forestal Wallings al suroeste de Antigua, elaborado por J. S. Beard (Servicio Forestal Colonial), el cual menciona la presencia de un bosque joven de postes entre los 15.2 y 21.3 metros de altura, un área basal de 22.8 m² por ha., un diámetro cuadrado medio de 20.6 cm y 20 especies de árboles. La misma área se volvió a inventariar en 1988, para entonces el rodal presentó una altura de cobertura entre los 9.0 y 11.0 metros, con un área basal de 19.8 m² por ha. (árboles mayores de 10 cm dap), un diámetro cuadrado medio de 19.3 cm y 26 especies de árboles; diez de estas especies fueron evidentemente nuevas en el rodal. El árbol de candela (Guettarda scabra) especie pionera, es actualmente la especie más común, mientras que el Roble españo (Inga laurina) lo fue en 1944. Los cambios en la composición del bosque están siendo fuertemente influenciadas por la corta “selectiva” de las especies de mayor demanda. Aparentemente el desarrollo hacia un bosque sucesional tardío esta siendo alterado por los efectos de esta actividad.

**Background**

The islands of Antigua and Barbuda constitute a Caribbean nation in the Lesser Antilles (Fig. 1). The principal island of Antigua is located 17º50’W longitude. When discovered by Colombus in 1493, Antigua was inhabited by the Arawak tribe. Early European settlement was deterred by the lack of freshwater springs, but Antigua was eventually settled by the British in the mid-1600’s. Full independence was gained from Britain in 1981.

Antigua has an area of 279.8 km² and a population of about 80,000. Population growth in 1983 was 1.3% and per capita GNP is US$1730 (Adams, 1985). Though tobacco was the first agricultural crop, the history of Antigua is closely linked to the sugar industry. Before the arrival of Europeans, Antigua was heavily forested. Establishment of a sugar industry prompted extensive land clearing, and by 1676 an estimated 70% of the island was in sugar estates. Land clearing continued after this date, and sugar was a principal commodity until commercial production ceased in 1972.

With decline of the sugar industry a mixture of vegetation has succeeded onto abandoned lands. The island is now about 20% forested, and the government owns about 60% of the land (Caribbean Development Bank, 1983). These secondary forest areas now provide fuelwood, posts, charcoal and other products. Some of these forest areas are extensively grazed by goats, sheep and cattle. The economy of Antigua is currently dominated by tourism, an industry that employs about 25% of the labour force of 30,000; agriculture contributes only about 8% of the GNP (Adams, 1985).

Antigua, an outlier of the Leeward Islands group, has a dry climate relative to neighbouring islands with higher relief. Mean annual rainfall is about 1092 mm, but distribution is erratic both within and among years, with prominent wet seasons and frequent long dry seasons. Mean monthly temperature ranges from 26°C to 29°C (Loveless, 1960).

Antigua has three district physiographic regions and associated soils (Charter, 1937). The northeast part of the island is a region of low hills with elevations to 90 m. Soils in this area are predominantly of the Fitches Suite, developed from limestone. The central plain, oriented NW to SE, is 15 m or less in elevation. Soils here are of the Otto Suite, developed over clays and sedimentary tuffs, and are neutral to alkaline with poor internal drainage. Most of Antigua’s forested land is located in the mountainous southwest region, dominated by the Shekerley Mountains and foothills. Ridgetops are rounded to flat and reach a maximum elevation of 402 m. Soils in this region are of the
Montero Suite, formed from andesite, agglomerates, and volcanic ashbeds and are thin and stony with poor internal drainage (Loveless, 1960).

Forest vegetation in the north and east of Antigua is considered xerophytic (Beard, 1955; Harris, 1965). In the southwest, where rainfall is highest, the forests are considered more mesophytic and are classed as semi-evergreen seasonal (Beard, 1955) or mixed evergreen-deciduous (Harris, 1965).

We know of no detailed botanical and quantitative information on the original forests of Antigua, and the secondary forests have not been extensively studied. Charter (1937), Cater (1944), Loveless (1960) and Harris (1965) give general information on the vegetation entering abandoned sugar lands, but Beard (1949) provides the most
complete, and evidently most recent, account of secondary forest composition, frequency, and tree size. This account is based on measurements of one 0.2 ha quadrat each at the Wallings and Brecknocks Reservoirs in southwest Antigua. Cater (1944) cites a 1912 agricultural report by H. A. Tempony indicating that the Wallings area was denuded in the early 1900’s; reforestation was recommended. The area was sown with an unknown mixture of tree seeds in 1915–16, but many resulting seedlings reportedly died. By 1944, however, the area was well forested under government protection and Beard (1949) described it as a young pole forest 15 to 21 m tall.

In recent years, some attention has been focused on forested areas, for both watershed protection and for provision of forest products. In preparation for forest management planning, a preliminary survey was conducted by the senior author to determine the composition and structure of Antigua’s secondary forest. We decided to perform the initial sampling in the catchment of the Wallings Reservoir, where J. S. Beard established his plot, and thereby ascertain any changes that may have occurred to this forest in the intervening 44 years.

**Methods**

Beard did not clearly mark his study plot, but described it as being at the bottom of the 53 ha (Cater, 1944) catchment area. Characteristics of the area suggest that Beard’s plot was probably on a lower north-facing hillside located at the south end of the 1.2 ha reservoir. This reservoir was created by a dam built during 1890-1900. In the 1988 survey, stone-lined water diversion channels and concrete sediment traps were used to reference a baseline. Plot sampling was done in a 1.7 ha area. Five transect lines about 23 m apart were established from the base line on a true south bearing. The departure points of the lines were marked with plastic or wooden stakes. Location of the first of 4 plots on each line was established at random; succeeding plots were located at 30.5 m intervals. A total of 20 plots was established.

At each sample point a 0.008 ha circular plot (5.07 m radius) was established, and all trees greater than 5.0 cm dbh were tallied by species, dbh, and total height. Data from the twenty 0.008 ha plots were analysed using a generalised forest inventory computer program in order to express stand parameters on a per hectare basis.

Regeneration was tallied on five 0.0004 ha plots. These plots, located one per transect at a 0.008 ha plot centre, were selected to represent different elevations. On each plot all woody vegetation under 30 cm in height was tallied by species and number of stems.

**Results**

Beard identified 20 species on his 0.2 ha quadrat in 1944. In addition to the 20 species, Beard also noted candlewood (*Guettarda scabra*), logwood (*Haematoxylum campechianum*), and turpentine (*Busera simaruba*) in the Wallings vicinity. Logwood, ironwood (*Exostema caribaem*), candlewood, and baby calabash (*Enallagma latifolia*) were observed at Brecknocks Reservoir, a drier site found about 2.5 km north. In the 1988 survey 26 tree species were tallied at Wallings (Table 1). Only 11 of these were common with those of the 1944 tally. In addition, eleven other species were noted in the surrounding woodland (Table 1). Nine species that Beard tallied were not found on our plot in 1988, and 10 species tallied in 1988 were not enumerated in 1944.

In the present forest, trees common in the dominant and co-dominant crown class are: locust (*Hymenaea courbaril*), mountain parry (*Linociera caribaea*), sugar grape (*Coccoloba swartzii*), cinnamint (*Canella winterana*), ironwood (*Exostema caribaem*), black loblolly (*Pisonia fragrans*), mahoe (*Daphnopsis caribaea*), and mango (*Mangifera indica*). The intermediate crown class is dominated by turpentine (*Busera simaruba*),
white cedar (Tabebuia pallida), and gunstock (Guazuma martinicense). The overtopped or suppressed species are sugar grape (Coccoloba pubescens), wattle (Eugenia spp.), candlewood (Guettarda scabra), white lobolly (Pisonia subcordata), lingamarl (Licaria salisifolia), Spanish oak (Inga laurina), milk (Ficus spp.), chinkswood (Bourreria succullenta), mahogany (Swietenia mahogoni), baby calabash (Enallagma latifolia), white prickle (Zanthoxylum martinicense), and Clusia sp.

Regeneration beneath the stand is dominated by wattle (Eugenia spp.), constituting over 95 per cent of the seedlings counted. Distribution of regeneration was variable; some plots were almost completely covered with Eugenia spp., while others had few seedlings but abundant leaf litter.

Other species in the vicinity of sample plots at Wallings Reservoir in 1988:

<table>
<thead>
<tr>
<th>Species</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia spp.</td>
<td>Acacia, cassie</td>
</tr>
<tr>
<td>Cedrela mexicana</td>
<td>Red cedar</td>
</tr>
<tr>
<td>Tabernaemoniana citrifolia</td>
<td>Milky bush</td>
</tr>
<tr>
<td>Cordia sulcata</td>
<td>Manjack</td>
</tr>
<tr>
<td>Ceiba pentandra</td>
<td>Silk Cotton</td>
</tr>
<tr>
<td>Psidium guajava</td>
<td>Guava</td>
</tr>
<tr>
<td>Artocarpus communis</td>
<td>Breadfruit</td>
</tr>
<tr>
<td>Carica Papaya</td>
<td>Papaya</td>
</tr>
<tr>
<td>Musa spp.</td>
<td>Banana</td>
</tr>
<tr>
<td>Annona muricata</td>
<td>Soursop</td>
</tr>
<tr>
<td>Manilkara zapota</td>
<td>Sapodilla</td>
</tr>
</tbody>
</table>

Marshall (1939) reported similar patterns for Eugenia spp. regeneration in Trinidad. Lingamarl (Licaria salisifolia) represented 1.4 per cent of the regeneration. Other species representing less than 1 per cent of each of the observed regeneration were black lobolly (Pisonia fragrans), mahogany (Swietenia mahogoni), mahoe (Daphnopsis caribaea), Spanish oak (Inga laurina), chinkswood (Bourreria succulenta), mountain parry (Linociera caribaea), and milk (Ficus crassinervia).

Comparisons

Beard measured tree diameters at girth in 1-foot classes, beginning with the 1–2 foot class. To make comparisons, we assumed midpoints of the girth classes and converted these to diameters in cm; thus the 1–2 foot girth class is considered equivalent to a diameter of 14.5 cm. Based on these conversions, we estimated that in 1944 Beard’s stand had 682 trees/ha, a quadratic mean stand diameter of 20.6 cm, and a basal area of 22.8 m²/ha. Average canopy height was stated by Beard to be 15 to 21 m. The comparable statistics for the 1988 survey (trees in the 10 cm class and above) are 680 trees/ha, a quadratic mean diameter of 19.3 cm, and a basal area of 19.7 m²/ha. Average canopy height is presently only 9.0–11.0 m, but individual stems of black lobolly, mountain parry, candlewood, and milk may reach 15 to 18 m.

Beard’s data indicate mango, Spanish oak, and black lobolly comprised 16.5 m² (73%) of the stand basal area (Table 2). In 1988 locust, black lobolly and mountain parry comprised 9.5 m² (48%) of total basal area. Mango and Spanish oak together now represent only 4 per cent of the basal area.

Candlewood is now the most abundant tree in the Wallings forest, but stems are of small diameter, and represent only about 11 per cent of the basal area of trees 5.0 cm dbh and larger. Beard noted this species in the vicinity of his plot at Wallings and tallied it at the drier Brecknocks Reservoir site; apparently its abundance at Wallings has increased considerably since 1944. Candlewood is considered a pioneer species that exploits forest openings and cleared land. Other species that are currently abundant are black lobolly, white cedar, sugar grape (Coccoloba swartzii), mountain parry, Spanish oak, and white
loblolly (Table 2). Of these species, white cedar is in greatest demand for boat construction and other local uses. Spanish oak is a preferred species for charcoal, while many of the other species may be used for charcoal, posts, and local construction.

Table 2. Per hectare comparison of species frequency and basal area for trees 10.0 cm dbh and above tallied on a 0.2 ha plot by J. S. Beard near Wallings Reservoir, Antigua in 1944 with trees tallied on 20 .008 ha plots in the same general vicinity in 1988.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Guettarda scabra</em> (Candlewood)</td>
<td>—</td>
<td>135.9</td>
<td>—</td>
<td>2.0</td>
</tr>
<tr>
<td><em>Pisonia fragrans</em> (Black loblolly)</td>
<td>113.7</td>
<td>86.5</td>
<td>2.7</td>
<td>3.2</td>
</tr>
<tr>
<td><em>Tabebulia pallida</em> (White cedar)</td>
<td>44.5</td>
<td>80.3</td>
<td>0.9</td>
<td>1.7</td>
</tr>
<tr>
<td><em>Coccoloba swartzii</em> (Sugar grape)</td>
<td>—</td>
<td>74.1</td>
<td>—</td>
<td>1.4</td>
</tr>
<tr>
<td><em>Linociera caribaea</em> (Mountain parry)</td>
<td>14.8</td>
<td>61.8</td>
<td>0.2</td>
<td>2.4</td>
</tr>
<tr>
<td><em>Inga laurina</em> (Spanish oak)</td>
<td>252.0</td>
<td>43.2</td>
<td>6.1</td>
<td>0.5</td>
</tr>
<tr>
<td><em>Pisonia subcordata</em> (White loblolly)</td>
<td>4.9</td>
<td>18.5</td>
<td>—</td>
<td>0.2</td>
</tr>
<tr>
<td><em>Licaria salisifolia</em> (Lingamarl)</td>
<td>—</td>
<td>18.5</td>
<td>—</td>
<td>0.1</td>
</tr>
<tr>
<td><em>Exostema caribaenum</em> (Ironwood)</td>
<td>—</td>
<td>18.5</td>
<td>—</td>
<td>0.1</td>
</tr>
<tr>
<td><em>Canella winterana</em> (Cinnamint)</td>
<td>—</td>
<td>18.5</td>
<td>—</td>
<td>0.5</td>
</tr>
<tr>
<td><em>Guazuma martinicense</em> (Gunstock)</td>
<td>24.7</td>
<td>12.4</td>
<td>1.5</td>
<td>0.1</td>
</tr>
<tr>
<td><em>Enallagma latifolia</em> (Baby calabash)</td>
<td>—</td>
<td>12.4</td>
<td>—</td>
<td>0.06</td>
</tr>
<tr>
<td><em>Hymenaeas courbaril</em> (Locust)</td>
<td>9.9</td>
<td>12.4</td>
<td>0.5</td>
<td>3.9</td>
</tr>
<tr>
<td><em>Haematoxylum campechianum</em> (Logwood)</td>
<td>—</td>
<td>12.4</td>
<td>—</td>
<td>0.4</td>
</tr>
<tr>
<td><em>Mangifera indica</em> (Mango)</td>
<td>74.1</td>
<td>12.4</td>
<td>6.7</td>
<td>0.3</td>
</tr>
<tr>
<td><em>Zanthoxylum martiniense</em> (White pickle)</td>
<td>4.9</td>
<td>6.2</td>
<td>0.1</td>
<td>0.06</td>
</tr>
<tr>
<td><em>Ficus crassinervia</em> (Milk)</td>
<td>4.9</td>
<td>6.2</td>
<td>0.1</td>
<td>0.7</td>
</tr>
<tr>
<td><em>Busiera simaruba</em> (Turbentine)</td>
<td>—</td>
<td>6.2</td>
<td>—</td>
<td>0.2</td>
</tr>
<tr>
<td><em>Clusia sp.</em> (—)</td>
<td>—</td>
<td>6.2</td>
<td>—</td>
<td>0.3</td>
</tr>
<tr>
<td><em>Terminalia catappa</em> (Indian almond)</td>
<td>—</td>
<td>6.2</td>
<td>—</td>
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<tr>
<td><em>Daphnopsis cariba</em> (Mahoe)</td>
<td>79.0</td>
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<tr>
<td><em>Cedrela mexicana</em> (Red cedar)</td>
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<td>—</td>
<td>0.1</td>
<td>—</td>
</tr>
<tr>
<td><em>Chrysophyllum argenteum</em> (Star apple)</td>
<td>4.9</td>
<td>—</td>
<td>0.1</td>
<td>—</td>
</tr>
<tr>
<td><em>Leucaena glauca</em> (Wild tamarind)</td>
<td>4.9</td>
<td>—</td>
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<td>—</td>
</tr>
<tr>
<td><em>Erythroxylum ovatum</em> (Wild cherry)</td>
<td>4.9</td>
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<tr>
<td><em>Persea americana</em> (Avocado)</td>
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</tr>
<tr>
<td><em>Cordia alliodora</em> (Spruce)</td>
<td>4.9</td>
<td>—</td>
<td>0.1</td>
<td>—</td>
</tr>
<tr>
<td><em>Tabernaemontana citrifolia</em> (Milkybush)</td>
<td>4.9</td>
<td>—</td>
<td>0.1</td>
<td>—</td>
</tr>
<tr>
<td><em>Nectandra membranacea</em> (Sweetwood)</td>
<td>4.9</td>
<td>—</td>
<td>0.1</td>
<td>—</td>
</tr>
<tr>
<td><em>Casearia guianensis</em> (Mountain parry)</td>
<td>14.8</td>
<td>—</td>
<td>0.2</td>
<td>—</td>
</tr>
</tbody>
</table>
Overview of Changes in Vegetation

The vegetation at Wallings Reservoir has changed considerably in 44 years, as a result of succession and natural and human disturbance. Spanish oak has shown the greatest decline since 1944, most likely due to harvesting for charcoal. Leucaena (*Leucaena glauca*), an early successional species, and nine other species occurring in low numbers in 1944, may still be present in the area but were not observed in the current survey. Mango, a relict of the agricultural period, has shown a dramatic decline, from 30% of basal area in 1944 to 2% in 1988. Few large mangoes remain; the others have evidently been harvested or have succumbed to competition by other species. There was virtually no natural regeneration of mango observed.

Silk cotton (*Ceiba pentandra*) now occurs infrequently but is the largest and tallest tree species on the reservoir at 75–80 feet (Plate 1). Most of these trees evidently invaded open areas following hurricanes and are thought to be 40 years of age or less. Logwood has been in the area for some time, but has not increased greatly in abundance. Large logwoods near the current tally plots are estimated to be about 80 years old.

Human use is apparently having a major impact on forest composition and development. Many trails occur in the area. They are probably used to enter to harvest both wattle (for construction of fish traps) and other species for charcoal and posts, as evidenced by stumps of small trees. Based on our comparative analysis, the forest has

Plate 1. The forest at Wallings Reservoir, Antigua, in 1988, with a large silk cotton (*Ceiba pentandra*) emerging from the canopy.
Table 1. Forest composition at Wallings Reservoir, Antigua, in 1988, based on a sample of twenty 0.008 ha plots, by species, frequency, diameter, and basal area, for trees greater than 5.0 cm dbh. Measurements are made in the general area where J. S. Beard established a 0.2 ha plot in 1944.

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>(Local Name)</th>
<th>Stems/ha by Dia. Class</th>
<th>Stems/ha</th>
<th>Mean Dia. m²</th>
<th>Basal Area cm²</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>(cm)</td>
<td>5–10</td>
<td>13–18</td>
<td>20–23</td>
<td>25–30</td>
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<tr>
<td>Ficus crassinerva</td>
<td>(Milk)</td>
<td>18.5</td>
<td>—</td>
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<td>Exostema caribaem</td>
<td>(Ironwood)</td>
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<td>Guazuma martinicense</td>
<td>(Gunstock)</td>
<td>18.5</td>
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<tr>
<td>Enallagma latifolia</td>
<td>(Baby calabash)</td>
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<td>—</td>
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<tr>
<td>Hymenaea courbaril</td>
<td>(Locust)</td>
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<td>Haematoxylum campechianum</td>
<td>(Logwood)</td>
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<tr>
<td>Busera simaruba</td>
<td>(Turpentine)</td>
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<td>Mangifera indica</td>
<td>(Mango)</td>
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<td>Clusia sp.</td>
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<td>Terminalia catappa</td>
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<tr>
<td>Species</td>
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<td>Carbohydrate 3</td>
<td>Carbohydrate 4</td>
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<tr>
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<tr>
<td><em>Daphnopsis caribaea</em></td>
<td>—</td>
<td>6.2</td>
<td>—</td>
<td>—</td>
<td>6.2</td>
</tr>
<tr>
<td>(Mahoe)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><em>Swietenia mahogoni</em></td>
<td>6.2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>6.2</td>
</tr>
<tr>
<td>(Mahogany)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><em>Buceras bucida</em></td>
<td>6.2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>6.2</td>
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<tr>
<td>(Whitewood)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td><em>Guettarda scabra</em></td>
<td>135.9</td>
<td>80.3</td>
<td>6.2</td>
<td>6.2</td>
<td>—</td>
</tr>
<tr>
<td>(Candlewood)</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td><em>Pisonia fragrans</em></td>
<td>61.8</td>
<td>30.9</td>
<td>18.5</td>
<td>12.4</td>
<td>12.4</td>
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<tr>
<td>(Black loblolly)</td>
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<td></td>
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<tr>
<td><em>Coccoloba swartzii</em></td>
<td>98.8</td>
<td>18.5</td>
<td>18.5</td>
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<tr>
<td>(Sugar grape)</td>
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<td></td>
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<tr>
<td><em>Inga laurina</em></td>
<td>80.3</td>
<td>18.5</td>
<td>—</td>
<td>—</td>
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<tr>
<td>(Spanish oak)</td>
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<tr>
<td><em>Tabebuia pallida</em></td>
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<td>24.7</td>
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<td>(White cedar)</td>
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<tr>
<td><em>Linociera caribaea</em></td>
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<td>24.7</td>
<td>18.5</td>
<td>12.4</td>
<td>6.2</td>
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<tr>
<td>(Mountain parry)</td>
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<tr>
<td><em>Coccoloba pubescens</em></td>
<td>61.8</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>(Sugar grape)</td>
<td></td>
<td></td>
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<tr>
<td><em>Pisonia subcordata</em></td>
<td>18.5</td>
<td>30.9</td>
<td>—</td>
<td>6.2</td>
<td>—</td>
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<tr>
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<tr>
<td><em>Eugenia spp.</em></td>
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<tr>
<td>(Wattle)</td>
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<tr>
<td><em>Bourreria succelenta</em></td>
<td>49.4</td>
<td>—</td>
<td>—</td>
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<td>—</td>
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<tr>
<td>(Chinkswood)</td>
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<tr>
<td><em>Licaria salisifolia</em></td>
<td>18.5</td>
<td>12.4</td>
<td>—</td>
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<td>—</td>
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<tr>
<td>(Lingamari)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><em>Zanthoxylum martinicence</em></td>
<td>24.7</td>
<td>6.2</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>(White prickle)</td>
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</table>
less basal area and lower canopy height than it did in 1944. This trend probably reflects increased intensity of cutting of preferred species; control of cutting in this officially designated forest reserve is possibly less effective than in former times. The intensity of cutting is apparently not permitting trees to reach large size; there are few trees in the stand over 30 cm in diameter. There is evidence of shifting cultivators in and around the forest, as well as evidence of recent charcoal burning within the sampled area. These activities appear to be detrimentally influencing stand development towards a more desirable, and presumably stable, mixture of both native and introduced vegetation.

Cutting of trees throughout Antigua annually yields about 7000 m³ of wood for charcoal (Caribbean Development Bank, 1983). This cutting is evidently done on a “selective” basis for the preferred charcoal species. This practice of partial cutting could be made compatible with the goal of maintaining the watershed in a continuous protective forest cover. It appears, however, that the forest will be dominated with early to mid-successional species of relatively low value and utility unless a plan for regenerating more preferred species, such as white cedar, Spanish oak, and mahogany is implemented. Maintenance of a component of late successional species in the stands may also enhance watershed values if these species should be deep rooted and promote water percolation into the soil mantle.

In the absence of permanent sample plots in Antigua, or other studies that would allow evaluation of successional trends, the present survey in the vicinity of Beard’s study of 1944 is valuable in documenting changes in forest vegetation. The need to protect forested areas for enhancement of watershed potential is now being recognised. Data from this study may provide guidance on where management efforts can be focused to maintain forest competition that will fulfill multiple use objectives.

REFERENCES


CATER, J. C., 1944. *Forestry in the Leeward Islands, Reports by the Conservator of Forests, Trinidad and Tobago*. Development and welfare in the West Indies, Bulletin 7. Office of the Conservator of Forests, Trinidad and Tobago, Port of Spain. 105p.


Requests for any publications received or noted below must be addressed to the publishers and NOT to the Association.


This book is based upon a workshop held at the University of Michigan in 1984, and the ten chapters were written in the following two years. The book addresses itself to the thinking behind how many individuals (of different sexes) are necessary to form a breeding population. The editor puts it more succinctly as "How much is enough?" Modern thinking has steadily increased the estimates of population size that is necessary for viability, bearing in mind the possibilities of genetic drift, catastrophes and epidemics. There has therefore to be a margin of safety built into any estimates of Minimum Viable Population (MVP), however these are arrived at. The book considers viability as an aim, with survival almost as a minimum acceptable goal, and accepts that it may often not be possible to achieve a realistic MVP. The treatment in most of the book's papers is mathematical, and relates principally to wildlife, rather than to plants. Nevertheless, as wildlife conservation is frequently an objective of forest management, even of plantations, there is much important information and guidance for foresters here.

P.J. Wood

**The Forest Alternative for Treatment and Utilization of Municipal and Industrial Wastes**


This is a substantial book devoted to the proceedings of a symposium held in June 1985 as part of the continuing education programme of the Washington State University. It offers a comprehensive state-of-the-art treatment of the use of forests in the disposal of waste water and sludge. Most of the contributors to the volume are from the USA, many of them from US government agencies. Five were from Australia, and their paper is a case study on the irrigation of tree plantations there, mainly in Victoria.

The first part of the book consists of programme overviews dealing with the disposal of wastewater and sludge, including wastes from the pulp and paper industry. Then follow 13 papers on environmental effects, including the assessment of risk and a discussion of the situation regarding heavy metals. Eleven papers discuss forest response, to water, nutrient and toxic inputs including some information on mortality. Six papers then look at programme implementation, the technologies involved and costs/benefits. Finally there are three sets of case studies: six papers on municipal wastewater, six on municipal sludge, and three on industrial and pulp and paper. There is a list of contributors with their addresses, and an excellent index.

The standards of the papers and the editing are very good, and the book is a wide-ranging compendium on the technical and managerial aspects of the treatment and disposal of wastes using forests, based mostly on experience in the USA where the technology is most advanced. As urban populations increase in other parts of the world, and the need for trees and tree products rises, the forest alternative for waste disposal will become more and more important. This book offers valuable guidance on the ways in which it can be done.

P.J. Wood

This paperback volume is a reprint of Frank Freese’s two valuable little books from the 1960’s, *Elementary Forest Sampling* and *Elementary Statistical Methods for Foresters*. Both of these have been reprinted in Britain before, and their value as practical teaching aids, and in the field has not diminished with time.

P.J. Wood


No-one walking through upland forests can fail to notice the effect of exposure on tree growth and productivity. This is examined for Sitka spruce in Scotland in this Bulletin. Five groups of site factors: elevation, location — both latitudinal and distance from the coast, site windiness and site temperature, geomorphic shelter (the sum of the angles of elevation to the skyline at the eight cardinal points of the compass) and aspect, and soil type, all influence productivity and the effect of each is assessed. Given these data, the author describes how to estimate the potential yield class for a site and using the data derives contoured maps showing the highest elevation at which a given yield class can be expected throughout Scotland. It is an interesting piece of work though the author is at pains to point out that the system is designed to augment the knowledge of practising field staff, not to replace it.

The work is of interest, too, for its co-operative nature. The project was initiated by Fountain Forestry Ltd and the Forestry Commission; it was jointly guided by the Forestry and Natural Resources Department of Edinburgh University and by the Forestry Commission and was wholly funded by Fountain Forestry.

J.D.B.


This is an update of Willis’s Dictionary of the Flowering Plants and Ferns but to describe it as just this is to do the work a dis-service. Willis’s Dictionary ran to eight editions, six in his lifetime and two published postumously by Airy Shaw at Kew. By the sixth edition, the work was truly a dictionary, with one comprehensive list of genera, plant common names and technical terms were omitted but even so the eighth edition ran to 1300 pages. In this latest version, titled The Plant-book, D. J. Mabberley has reverted, in part, to the principles of the earlier editions of Willis. Not in their entirety; you will have to go to Willis (or elsewhere) to find that aduncate means bent like a hook, but you will find that afrormosia is the common name for *Pericopsis elata* and just one of the examples of a generic name retained in popular use though abandoned by the taxonomist.

As in Willis, the book sets out to list all the accepted generic and family names and gives many commonly used English names. For each genus there is information on its
family, the number of species, the geographical distribution and economic importance; each family entry gives the number of genera and species, the classification of the family, its morphological characteristics, and the principal genera. The Plant-book differs from Willis in using Cronquist's 1981 classification of the angiosperms; Willis largely followed Engler and there is no comparison between the two systems, though references are given where such comparisons can be found. Source references include some 600 floras, handbooks and periodicals and there is a comprehensive list of authors' names, with dates, itself a useful reference and far more comprehensive than those in the early editions of Willis. The format is unusual, with a narrow, 120 mm wide, page and the book is described as a portable dictionary. It fits the hand well but would need a fairly deep pocket if carried far.

Such a book is an invaluable reference and most foresters and other plant scientists will find it useful sooner or later. To compile it is a major undertaking, even when there is a basis on which to build, and a great debt is owed to those with the industry to carry through such a task. Inevitably, as the author quoting Dr Johnson says in the final paragraph of his Preface, it is the lexicographer's lament that readers only remark on a dictionary when what they want can not be found. With the inclusion of common names it is inevitable this will happen, but it in no way detracts from the usefulness of the work. There is and ever will be a need for such reference books.

J.D.B.

*Commonw. For. Rev.* 67(3), 1988


This interesting and generally readable production is the work of 21 experts from the Forest Service and a number of Universities in the United States. It is structured so to proceed from the general to the particular both throughout the book and within each of the four Parts. This makes it possible either to gain an appreciation of the general principles or delve into the details or both. Each Chapter ends with a comprehensive and valuable list of references.

A casual glance at the title might initially lead to the belief that this is another book on weed control. Nothing could be further from the truth. As the Editors state in Part 1 “... the strategic concept of vegetation management has replaced the more tactical discipline of weed control”. The book is, in fact, concerned with the issues central to this strategic concept which are the economic injury level and the economic threshold. The economic injury level is defined as the lowest density or size of a pest problem (e.g. weeds) which will cause economic damage and the economic threshold as the level of a pest problem at which control measures should be initiated to prevent an increasing pest problem from reaching the economic injury level. It is considered that the economic threshold is usually a more useful action point because once the economic injury level has been reached the only solution is an expensive cure. The book describes the current state of knowledge on these two concepts within the context of forest vegetation management.

Part One (Forest Vegetation Management Perspectives) commences with the very interesting Chapter from which the above quotation was culled. The three Chapters which follow are concerned with the problems of forest vegetation in specific regions of the U.S. and are of rather narrow interest. Chapter 5 deals with the principles governing plant-environment interactions. Since it considers the ecological aspects, interference and competition and the physiological basis of competition it is clear that those involved
in the development of agroforestry systems would gain much from a scrutiny of this Chapter. Chapter 6 is an overview of vegetation management alternatives and although interesting seems to try and accomplish too much. Little of it would be of much use to a European forester.

Part Two considers conifer response to vegetation management. The first Chapter is an extremely useful account of the general principles and pattern of conifer growth and yield particularly in relation to stocking levels. This provides the essential quantitative basis for examining competition problems. The authors would, however, be advised to review their understanding of the British concepts of yield class and production class. The three Chapters which follow are case studies on the interaction between conifers and competing vegetation. The methodology described is interesting although the conclusions reached do not seem to reveal anything very new. Perhaps, almost inevitably, some of these studies dwell rather tediously on such things as the use of “keywords” in the operation of a specific computer model and on lists of data bases available. This is of little value to those who have no access to or use for these models and may well be irrelevant to those who have but already know how to use them.

Part Three is concerned with evaluating forest vegetation management options. It starts with a Chapter which considers such things as the cost components and current cost ranges for vegetation management activities, recent costs and timber price trends and the influence of project and site factors on costs. It provides the basis for the economic evaluations which follow. The initial reaction is to query the usefulness of such information but the writer knows from experience how difficult such data are to compile and, although soon out of date, continue to provide a useful source of reference. The second and final Chapter gives examples of economic analyses of the silvicultural effects of vegetation management both at the stand and at the forest level. It considers two approaches to stand-level analysis using Douglas fir as an example and a third case where dynamic programming is used to show how the optimal regime varies as the level of vegetation competition with loblolly pine increases. It demonstrates how the reduction in value resulting from different levels of competition can be calculated. Forest-level effects are assessed using the “allowable cut effect”. As the authors say, stand-level analysis measures the investment efficiency of forest practices whereas the allowable cut effect is appropriate where macroeconomic regional production and employment analyses are to be undertaken.

Part Four is entitled “Synthesis”. In the first Chapter the application of the principles presented in the previous Parts (ecological, mensurational and economic) to the management of individual stands is discussed. It describes, in a logical sequence, the procedures which a forest manager should follow in prescribing and controlling forest vegetation management activities. The final Chapter is, in some senses, the key Chapter in the book because it summarises the important biological concepts and biometrical patterns established in forest vegetation management research. It makes recommendations for maintaining progress in this field.

In general I found this to be one of the most interesting and rewarding publications which I have received for some time. It explains in a progressive way the problems and complexities of vegetation management. It shows clearly how important it is to develop an understanding of the subject by careful consideration of the ecological dynamics and competitive relationships within a forest. The book deserves a place on the shelf of every forest manager but the price will probably restrict it to those of libraries. It will undoubtedly feature strongly in the reading lists for all courses concerned with land management.

J. C. Hetherington

This is an example of the kind of thing that ITDG does extremely well — a short, portable, comprehensive guide for the keen non-specialist on a technical subject. It lays its emphasis on good quality thatch with the maximum durability and effectiveness, and describes modern methods which are an advance on some traditional types of short lived grass or palm roofs. The book also contains advice on the minimization of risks particular to thatched roofs, notably fire and it is clearly illustrated with line drawings showing practical aspects of the skills described. Rural development forestry still demands skills in simple field engineering, and this should be a valued text in many parts of the world.

P. J. Wood
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RESEARCH NOTES


Abstract
A major constraint on the multiplication of many woody perennials for use in rural development forestry is poor seed supply and handling. Seed requiring scarification is often treated inadequately as a result of a scarcity in terms of skill and capital. The hot-wire method of scarifying seed described in this paper is applicable to such conditions as it is a cheap, effective method with a broad applicability to a number of seed types.

The hot-wire scarifier is used by applying a wire tip heated by electrical resistance to the testa of 'hardseeded' seed. This method damages the testa sufficiently to allow the imbibition of water. The paper describes the results obtained from treating ten 'hardseeded' species.

Introduction
The work described here is part of ICRAF's programme of evaluation of multipurpose trees and shrubs (MPTS). The term "multipurpose" refers to the planned use of trees and shrubs in land use systems to produce more than one product or benefit. Much of this work has been and is being carried out in collaboration with the Forest Seed Centre at the Kenya Forestry Research Institute, (KEFRI) at Muguga, Kenya.

Many of the woody perennials of interest for incorporation into agroforestry systems and rural development forestry systems have germplasm which displays hardseededness, that is, seed with a testa which prevents water imbibition and therefore germination. The condition can be a particularly difficult problem with species in the Papilionaceae/Mimosaceae as for example in the case of many of the African Acacias and other families including the Rosaceae and Malvaceae.

A major constraint to the multiplication of many woody perennials for use in rural development forestry and agroforestry is poor seed supply and handling. The phenomenon of hardseededness and its treatment has been well researched for many species already, but there remains much work to be done on several MPTS of potential importance. Physical seed scarification, immersion of the seed in sulphuric acid, hydrogen peroxide or in boiling water are common practices used to overcome 'hardseededness'. However, these techniques often involve a high input in terms of skill, time and capital outlay. The use of acid can be dangerous. These are all costs the small farmer, or more importantly, the small rural nursery, may find difficult to meet. As a result, successful scarification using the standard techniques tends to be limited to the larger well-equipped and better staffed nurseries which tend to be few in number and generally at considerable distances from the sites where the seedlings are to be planted.

Any technique, therefore, that overcomes hardseededness, is easy to apply, reduces the cost of treatment and makes seed prepared for germination more readily available to the small rural nursery (and therefore the end user) could make a valuable contribution to the development and use of MPTS in rural development. The evaluation of the hot-wire scarifier was undertaken as it appeared from the information available to offer all of the above mentioned features.
Background

The hot-wire seed scarifier

The technique of constructing and using a home-made hot-wire seed scarifier has been described by Robbins (1986). Commercial versions of hot-wire seed scarifiers are now also available (TELEKTRO, Denmark) and have been evaluated by DANIDA (Stubsgaard 1986). Robbins (op.cit) reported the successful treatment of twelve species and a time saving advantage over more conventional scarification methods during evaluation trials in Nepal.

Construction of the hot-wire scarifier

The writer constructed two hot-wire scarifiers along the lines described by Robbins (see Figure 1). Construction was quick and easy, the materials cheap (cost including charger — KShs.1400, 1987 i.e. less than US$100) and readily obtainable locally. The main expense is the battery and charging unit but in practice, a battery installed in a vehicle can be used to reduce costs, although it is somewhat less convenient than a separate battery.

A battery and charger used exclusively for large scale scarification could make savings in terms of time, safety, materials (such as sulphuric acid) and improved germination to offset the capital cost in a few months.

Features of the hot-wire scarifier

The scarifier consists of a short length of thin wire which is doubled to form a small loop and which is heated by an electric current. This heated wire is applied to the testa of the seed; the temperature is controlled by adjusting the length of the resistance wire (see Figure 1). Experience has shown that the best place to apply it is the shoulder of the seed coat opposite the radicle or micropyle end of the seed (i.e. the distal or cotyledonary end). In some seeds, the radicle end is not immediately obvious and in order to save time locating the radicle, many species can be burned on the pleurogram, (see Figure 2). This is especially true of many of the African Acacias which are spheroid and will present a
distinct pleurogram when laid flat. Samples of seed of different species which had been scarified in this way, (see Table 1), were examined by cutting across the burned area. Although provision had been made in the experiments to use wires at different temperatures, in practice, the best results were obtained by keeping the hot-wire at as high a temperature as possible (a bright yellow colour). At these temperatures, the wire becomes soft and easily deformed and must be applied without pressure and only very briefly to the seed coat when a slight ‘pop’ or ‘crackle’ sound will be heard.

If the hot-wire is applied with any substantial pressure, it may distort or even break. Moreover, attempting to burn right through the seed coat results in the seed sticking to the wire, causing unnecessary damage to the cotyledon (s) or even death of the embryo by overheating. This is especially true in the case of small seed such as Acacia mearnsii, for example. Burning completely through the seed coat is not necessary, only heat cracks in the testa are needed to overcome ‘hardseededness’. (Coe, Personal Communication 1987). This is directly analagous to the results obtained by creating fractures in the seed coat by impaction or shallow scores by mechanical scarification of the outer seed coat.

It might be thought that treating individual seeds is time consuming, but in practice the process can be rapid, several hundred seed per minute being treated in a single operation. Treating individual seeds allows visual assessment of seed quality and counting of seeds into batches to be done with no extra effort. With small seedlots which

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**Table 1**

Conventional Scarification Methods Used On Test Seeds

<table>
<thead>
<tr>
<th>Species</th>
<th>Best Known Conventional Scarification Method*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia albida</td>
<td>Nipping</td>
</tr>
<tr>
<td>Acacia mearnsii</td>
<td>Boiling water till cool (24 hours)</td>
</tr>
<tr>
<td>Acacia melanoxylon</td>
<td>Boiling water till cool (24 hours)</td>
</tr>
<tr>
<td>Acacia nilotica</td>
<td>Nipping</td>
</tr>
<tr>
<td>Acacia polyacantha</td>
<td>Boiling water till cool (24 hours)</td>
</tr>
<tr>
<td>Acacia tortilis</td>
<td>Concentrated sulphuric acid (40 minutes)</td>
</tr>
<tr>
<td>Adenanthera pavonina</td>
<td>Concentrated sulphuric acid (60 minutes)</td>
</tr>
<tr>
<td>Caesalpinia spinosa</td>
<td>Concentrated sulphuric acid (30 minutes)</td>
</tr>
<tr>
<td>Calliandra calothyrsus</td>
<td>Nipping</td>
</tr>
<tr>
<td>Delonix regia</td>
<td>Concentrated sulphuric acid (180 minutes)</td>
</tr>
</tbody>
</table>

*Information supplied by Forest Seed Centre, Kenya Forestry Research Institute.
have been expensive and difficult to obtain, such individual attention is more than justified.

Robbins (op.cit.) suggests that seed should be held firm using double-sided sticky tape to prevent them adhering to the hot wire. In the trials described here, this only became a problem if the wire was held too long on the seed coat, or if the tip was kept at too low a temperature. Some seeds e.g. *Schinus molle*, with a resinous coating on the testa, do stick to the hot wire whatever the temperature and can ignite in a spectacular fashion.

**Methods and Materials**

Ten species, some of which are important MPT species, were included in this trial. (See Table 1). These species were chosen as they are widely used in agroforestry and social forestry, known to be hardseeded, vary physiologically and were readily available. One hundred seeds of each of the above species were each subjected to: (a) Hot-wire scarification, (b) Conventional ‘best known’ scarification (information supplied by the Forest Seed Centre, KEFRI. See Table 1) and, (c) No treatment.

For tests of germination, seeds were placed on filter paper in petri dishes in twenty-five seed replications. They were arranged so that they were separate from each other to prevent fungicidal spread. No fungicidal applications were made and the petri dishes were arranged randomly on a laboratory bench away from direct sunlight. Germination counts were made at regular two-day intervals. Germinated seeds (i.e. seeds with vigorous radicles at least twice the length of the longest dimension across the seed) were discarded on counting. The filter paper was regularly wetted with distilled water.

**Results and Conclusions**

Cumulative germination trends for all ten species were plotted (see Figures 1–10). As can be seen from the graphs in over half the tests, hot-wire scarification was found to be at least as good as the ‘best known’ scarification method and in some cases was found to be considerably better e.g. with *Acacia tortilis*.

*Acacia melanoxylon* showed particularly poor germination probably because of heavy handedness on the part of the operator and it is evident that some species may require extreme care in treatment. Nevertheless, hot-wire scarification is considerably safer than using agents such as acid or boiling water. Acid treatment in particular requires careful control to ensure successful scarification i.e. ensuring that seeds are completely dry. Moreover each new seed accession has to be tested for the scarification period required. Hot-wire scarification appears to be broadly applicable over a wide range of seed types, as well as being cheap and non-messy.

Germination values were calculated as it was perceived that hot-wire scarification increased the speed of germination in some cases. This is an expression of both the total germination at the end of the test period combined with an expression of ‘germination energy’ i.e. speed of germination (Czabator 1962). The calculation is as follows:

\[ GV = (\text{final MDG}) \times PV \]

\( GV = \) germination value
\( MDG = \) mean daily germination
\( PV = \) maximum mean daily germination reached at any time during the period of the test
An alternative method (Djavanshir and Pourbeik 1976) said to be more closely related to the survival of plants in field nurseries was also used.

The calculation is as follows:

\[
GV = \frac{(DGS/N) \times 6P}{10}
\]

GV = germination value
GP = germination % at end of test
DGS = daily germination speed i.e. cumulative germination
N = number of daily counts

Histograms of the values obtained from both methods have been lotted (see Figures 11–12). Apart from *A. nilotica*, *A. albida*, *A. melanoxylon* and *Adenanthera pavonina* the hot wire seeds show enhanced germination values. This may have several advantages to both the researcher and the field worker. Enhanced germination speed allows more rapid assessment of the seed quality aiding decisions with respect to replanting. Where seed is direct planted, increased germination speed will allow the seed to respond more rapidly to what more are often transient favourable environmental conditions for germination.

In this author's experience, the seed after hot-wire scarification lends itself well to further storage if it is kept dry. This has considerable implications for the distribution of pre-scarified seed to small nurseries and individuals with limited resources. Acid and boiling water scarified seed can also in some cases be dried after treatment and stored if kept dry.

However, this process requires care in both the scarification process and to ensure the seed is not left moist enough to encourage partial germination or fungal attack. An evaluation of the storage potential of hot-wire scarified seed using some of the species mentioned has been instituted at the Forest Seed Centre, (KEFRI), Muguga, Kenya. The trial has now been operating for six months. Initial observations of this trial and work done at the DANIDA Forest Seed Centre has been encouraging, (Lauridsen and Stubsgaard, 1987).

Acknowledgements

I wish to record a special note of thanks to Mr. P. J. Wood (ICRAF) and to all the staff of the Forest Seed Centre (KEFRI) who have provided me with considerable help and advice with the above work. My thanks are also due to a number of the senior scientific staff at ICRAF who provided me with guidance in the writing of this paper.

Key to Graphs

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<tr>
<th>HWS</th>
<th>Hot-wire Scarification</th>
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<tr>
<td>CS</td>
<td>Conventional Scarification</td>
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<td>NS</td>
<td>No Scarification</td>
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<td>ACP</td>
<td><em>Acacia polyacantha</em></td>
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<td>ACT</td>
<td><em>Acacia tortilis</em></td>
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<td>ACN</td>
<td><em>Acacia nilotica</em></td>
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<td>ACMe</td>
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<td>CAC</td>
<td><em>Calliandra calothyrsus</em></td>
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<tr>
<td>CAS</td>
<td><em>Caesalpina spinosa</em></td>
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<tr>
<td>ADP</td>
<td><em>Adenanthera pavonina</em></td>
</tr>
<tr>
<td>DR</td>
<td><em>Delonix regia</em></td>
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The Oxford system of decimal classification for forestry (ODC); further development after the 18th IUFRO World Congress by Regina Schenker

Summary

In 1981 IUFRO assumed responsibility for the control, maintenance and development of the “Oxford system of decimal classification for forestry” (ODC). Project Group P.6.01-00 was set up and its work outlined. The system is of value to forestry research now, and can make a greater contribution in the future as it can overcome language barriers and is suitable for computer processing. The results of the 18th IUFRO World Congress are presented.

Keywords: Oxford system, computer processing
Oxf. No.: 945.14

Introduction

Information problems which affect foresters are due to the flood of publications, the different languages in which they are published, the vague citation by authors and bibliographers, and the classification systems. The forester has to deal with the first three points, as the information worker wants to look at the classification.

High technology in forest research was the theme of Division 6 of the 18th IUFRO World Congress in Ljubljana, Yugoslavia in September 1986. New developments in high technology have superseded the ODC system for many years. A few scientists shared the opinion that the Oxford system is much too restricted in its hierarchical structure compared with the key word systems coming from the United States. However the Oxford system has proved that it is flexible enough for computer processing.

Since the 17th IUFRO World Congress in Kyoto 1981, foresters, documentalists, librarians, and translators of the forest research stations in Austria, Australia, Finland, France, Germany (FRG), the United Kingdom, the Netherlands, Norway, Poland, Switzerland, the USA, and Yugoslavia have all contributed to the development of the ODC. The result is the amendment No 7 to the Oxford system, consisting of 49 changes and 17 new numbers. These have been consolidated with the former amendments No 1–6 (1957–1967) and published in both systematical and alphabetical order, so as to facilitate classifying work. The lists conform to the ODC layout so that they can be integrated into the system before a new, expanded edition is actually printed. The English version of the amendments was completed in 1983, the German version in 1984.

The task and principles of the ODC-Group

The Committee can only fulfil its task as co-ordinator if each active member independently submits all relevant information on the basis of the following criteria. The principles were taken from the “Joint FAO-IUFRO Committee on Bibliography and Terminology”, which was responsible for the ODC between 1950 and 1974:

i) New sub-divisions should not be accepted if they are such that only a specialist in the subject concerned would be capable of applying them correctly.

ii) New sub-divisions cannot be accepted if they duplicate existing sub-divisions, having the same sense, in some other part of the system.
iii) Major proposals for revision or extension, i.e., those affecting a whole subject, have to be referred to the appropriate Division(s) of IUFRO, which should be requested to supply the Committee with a unified and detailed statement of its requirements, subject to the above principles. It is, of course, understood, that specialists would be free, as before, to make their own domestic sub-divisions of ODC numbers.”

Each new amendment is first printed in English in the “IUFRO News”, so that it reaches as many ODC users as possible. Reprints are sent to all ODC users on the Group’s mailing list. Other users may request copies from the Group leader.

Once the original in English is approved and printed, the changes are first translated into German and French, two others of the official languages of IUFRO. The Committee may be consulted for co-ordinating work, and following approval by the Committee a finalised version is printed. These translations are published in the “IUFRO News”.

The following are some of the most frequent reasons that various proposed expansions or amendments have not been integrated into the system.

— The Committee could not agree on the systematical sequence.
— The proposed notion was a synonym, to be included in the alphabetical index only.
— The concept was of too local interest. In such cases the system is flexible enough to allow the breakdown of single numbers if really necessary.
— The proposal is a formal, not a subject number, e.g. a hand-book, a series, a tool, a method, etc., including countries, areas, etc. These can be taken from the latest edition of the “Universal Decimal Classification”.

The procedure for the expansion of, and amendments to the system is published in detail in the congress report for all those directly concerned.

A new edition of the Oxford system in English is in preparation including all expansions and amendments, which have been accepted from 1954 to date.

**Further developments in computer processing**

In the past 15 years the enormous potential of computer technology has led to intensive promotion of forest terminologies and thesauruses. Today a whole reference library of these is available. Between 1973 and 1984 alone, 358 forestry dictionaries, terminologies, and glossaries were published.

Nevertheless, definitions vary from one edition to another and are not easy to manipulate. Also, the people concerned encounter great difficulty in interpreting terms that are assumed to be universally understood. A further problem is that keywords and their applications often change within a short period. For those expected to supply literature as rapidly as possible, the computer is a quick means of communication; references can be found within seconds. That, however, is of little help if it takes months to obtain an actual copy of the publication, if at all. Many users to not appreciate this discrepancy. Furthermore, since the user’s native language is often very different from that used in the English headings of a controlled vocabulary, trained on-line documentalists are needed to overcome the language barrier and the method of application.

Many databases have gone commercial in recent years, separated to some extent from the scientific institutes, whose libraries date back often more than a hundred years, and have concentrated on documentation. Consequently, the quality of the product suffers greatly. Librarians, as the guardians of literature and the most immediately affected, are the first to realise this.
If the present inaccuracy in citation by databases continues, it will not be long before only a Sherlock Holmes will be able to extract any information; and, as we all know, fewer and fewer people have the time or the patience for such painstaking work. After Mr. S. Schrader's statement (senior documentalist of the Federal Research Centre for Forestry and Forest Products in Hamburg), there are now some 3000 literature databases throughout the world, 11% of them dealing with the natural sciences. He also pointed out in Kyoto, 1981, that "the main purpose of this paper is to draw attention to the limits of database use because of language barriers. These barriers can be overcome in joint efforts of all who are interested in improved methods for the exchange of information".  

Many IUFRO member countries have responded to the appeal of the "Joint FAO/IUFRO Committee on Bibliography and Terminology" already in 1957 for the regular publication of forest bibliographies. All of these forest literature organisations have a long bibliographical tradition, and many of them have continued to use the Oxford system in their classifying work. This is a great advantage for the exchange of references between one nation and another. Those who have worked with the ODC know that every change in a system adversely affects big collections.

In the near future, more national databases dealing with forestry should be able to complement international big databases with their local literature. The Oxford system can help to surmount the language barrier.

The results of the 18th IUFRO World Congress, 1986

In Ljubljana, only a few members of our Group were able to attend the Congress; present were colleagues from Austria, England, Finland, West Germany, Hungary, Nepal, Norway, the USA, Yugoslavia and Switzerland.

The following points were pleasing developments to report:

1) For the first time in the history of IUFRO, all symposium articles have been classified with the Oxford system.
2) Due to great demand, the English edition of the Oxford system had to be re-printed.
3) The "Allgemeine Forstzeitschrift", Munich, has published a catalogue for the past 40 years, using the Oxford system.  
4) After using key words for many years, the documentation centre of the "Bundesforschungsanstalt für Forst- und Holzwirtschaft", Hamburg, has re-introduced the numerical Oxford system.
5) The documentation centre of the "Forstliche Bundesversuchsanstalt", Vienna, can distribute their output on lists and catalogue cards from 1986. They are classified with the Oxford system.
6) In the past five years the number of editors classifying articles in periodicals, specialized bibliographies, and the contents of national forest bibliographies with the Oxford system has considerably increased.
7) Comments made at the Congress revealed that many foresters classify their personal literature collection with the ODC.

The previous tendency to believe that the Oxford system was less suitable for computer processing than keyword systems may be correct to some extent, especially when English is the only language concerned. However, the picture is very different when several languages have to be manipulated.

At the IUFRO Congress in Kyoto in 1981 Mr. W. Finlayson, former director of the "Commonwealth Forestry Bureau" (CFB) in Oxford, UK, said that "the Bureau has in effect joined the "key word" camp in the long-standing controversy between verbal and
numerical bibliographic classifications. It would please everyone, including ourselves, if we could do both, but we have severely limited resources”. Further, Mr. V. P. Aitro, Librarian at the “Pacific Southwest Forest and Range Experiment Station” in Berkeley, USA, remarked that “the best developed hierarchical subject index to date to display these pure forestry relationships is the CFB index to Forestry Abstracts (FA). If used in conjunction with the Oxford Classification System, the CFB index to FA should provide users with logical breakdowns of topics to meet any practical indexing need”.10

At the Congress in Ljubljana in 1986 some scientists expressed their opinion that the system is too restrictive. Is that because the title includes the term “for forestry”? Yet is there any field today that is not related to forestry in some way? Those developing the system, both when it was first designed around 1900 and when it was revised between 1930 and 1968, were so far-sighted that there is no field that is not or could not be incorporated in it.

Speaking with participants at the Congress, it was obvious to realize that following the boom in key words, numerical classifications seem to have regained their popularity. Why? The problem of definitions is becoming increasingly difficult, even within one language, and also in forestry, since 70% of the databases use English.

Outlook

Today the ODC-Group comprises 181 registered members from 60 countries; the Committee includes representatives of 3 forest research institutes and 21 active members.

Under the sponsorship of the IUFRO, the Oxford system has regained ground worldwide. The computer application of the Oxford system is already being employed at the forest research stations in Argentina, Austria, Federal Republic of Germany, Finland, France, Great Britain, India, Japan and South Africa. 11

If the technical development and the close international co-operation continue at its present pace, the concurrent use of both systems will find more interested users. This means that those who are more familiar with numerical classification can search the literature on that basis, while those more accustomed to using keywords can use the other approach.

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CH-8032 Zürich, Switzerland

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0844 279571
Foresters Education

What attributes will our next generation of foresters require? They will need to cope with more than the growing of trees, they will be managers of the land and its water and of its air. Core subjects will include the study of the rocks and the soils they produce, studies of climate, limitations imposed by ranges of temperature, rainfall and windspeed. Hence, a basic grounding in chemistry and physics. Vegetation will be met in many forms along with the wild and cultivated life it supports. This suggests botany, zoology and entomology. Management skills need to be learnt or acquired by experience. Decisions should be made in the knowledge of the options open and an assessment of the outcome of alternative courses of action. The implementation of the decision may need the support of others with whom the forester must communicate. Some accountancy skills will help to calculate the desirability of the results obtained. The development of responsibility can take place within the comradery of the peer group and is unlikely to be nurtured when facing a T/V monitor. Familiarity with computers, information technology developments and satellite imagery will pose little more problem than erstwhile students found with slide rules, girth tapes and hypsometers.

Communication skills must be based upon a sound understanding of the forester’s native tongue with some familiarity with at least one other language. Each additional attribute adds to the personality and in many fields compliment each other. The ability to absorb information and to make rational decisions based upon it will always be relevant; for the forester who may have no one else to rely upon, this ability may be vital. The forester should be able to drive before being let loose on the world, should be able to navigate; it helps to be able to fly, to swim and sail and to fish. Familiarity with the social graces will not come amiss and can well be included in the early days of education.

In summary, your enthusiastic forestry student has spent some time working abroad between leaving an Outward Bound School and attending a science course at university. The course is not an end in itself but it opens the door to a number of experiences which each adds a facet to the character. The resulting diamond may bring a sparkle to the landscape or play an abrasive role in an industrial context but it is hoped that sufficient inner light will be retained to illumine a younger generation and that the rewards will be sufficient to offer some time to enjoy the woods of the forester’s own creation.

The Future of the Tropical Rain Forest

The above title for a two day conference in June, 1988 in Oxford gave the opportunity for 27 organisations to voice their several conflicting viewpoints under the paternal chairmanship by members of the OFI. It is hoped that the following list of contributors will whet the interest of members who may then wish to contact the OFI, South Parks Road, Oxford OX1 3RB for the collected abstracts. Introduction by Sir Crispin Tickell, KCVO; The first century of tropical silviculture by Dr. H. C. Dawkins; Conservation and management of the genetic resources by Dr. N. M. Collins; Tropical deforestation and global climatic change by Professor Ann Henderson; Ethical considerations in rain forest conservation and development; The Tropical Forestry Action Plan by Dr. M. R. de Montalemberth; TFAP environmental concerns and donor response by John Spears; TFAP environmental implications by R. Winterbottom; TFAP people and profits? by Ms Chee Yoke Ling; Malaysia — a responsible supplier of tropical timber products by
Ir. Lew Wing Hing; The role of the ITTO by Dr. J. Evans; Tropical rainforest campaign by FOE by K. Thomson; The UK Timber Trade’s concern for the future of the tropical rain forest by Dr. G. K. Elliott; The role of the ODA in the future of the tropical rain forest by W. J. Howard; The role of the media in influencing public perception and response by Dr. R. Silverstone and Priorities and trends in tropical rain forest research by Dr. J. Hall.

On the same theme, the November, 1988 issue of *American Forests* also shows the scope of interest with the following papers:- ReLeaf for Global Warming by R. N. Sampson; Addressing the challenge of climate change by T. E. Wirth; Tarzan’s Jungle and other misconceptions by D. A. Boerner; The politics of tropical deforestation by T. M. Pasca; Global view of a tropical disaster by S. Postel; Is sustainable harvest possible in the tropics? by G. Budowski; Finding forestry alternatives by F. H. Wadsworth; Life and death in tropical forests by J. P. Jackson; Creating a tropical forest by W. Kaufman and among other articles, Tropical forests and you by L. Daily.

**IUFRO’s working parties on tropical silviculture**

The urgent problems of tropical forestry — deforestation, soil conservation, fuelwood shortages, gene conservation and the like — are a main concern of the International Union of Forest Research Organisations. The Subject Group on Tropical Silviculture (SI.07-00) comprises working parties covering natural regeneration, plantation forestry and dry zone foresting, and has special interest working parties on Dipterocarps, Mangroves, Rattans.

All research workers from IUFRO member organisations are eligible to become members of these working parties, and interested scientists are invited to write to the Chairman of the individual working parties (see IUFRO News No. 55 of 1987) or to the following:

P. J. Wood,
IUFRO Subject Group Leader SI.07.00,
C/o Oxford Forestry Institute,
Oxford OX1 3RB,
England.

M. Corbasson,
IUFRO Subject Group Leader SI.07.00,
Centre Technique Forestier Tropical,
45 bis Ave de La Belle Gabrielle,
F-94130 Nogent Sur Marne,
France.

Tang Hon Tat,
IUFRO Subjection Group Leader SI.07.00,
Sabah Foundation,
Box 1201,
Kota Kinabalu,
Sabah,
Malaysia.

(For Latin America especially)
R. Salazar,
IUFRO Chairman SI.07.09,
CATIE,
Turrialba,
Costa Rica.

**Statement of the Second Bellagio Meeting on Tropical Forestry 30 November and 1 December 1988**

1. A meeting of representatives of bilateral and multilateral donors, development banks, non-governmental organizations and specialists from developed and developing countries was held at Wiston House in the United Kingdom to consider the report of a Task Force on Tropical Forestry Research. The Task Force had been convened at the request of the Bellagio I conferees in July 1987.

2. The Bellagio II meeting concluded that:
   (i) the deforestation crisis identified by the Bellagio I meeting had intensified;
   (ii) the 10 recommendations made at Bellagio I need to be monitored. Although
Bellagio II focussed on strengthening tropical forestry research, the other points needs to be reviewed. The sponsors of Bellagio II agreed to undertake this task and prepare reports on their overview;

(iii) the Tropical Forestry Action Plan endorsed by Bellagio I is now being implemented and plans are being prepared for many countries under FAO's co-ordination. The meeting also took note of recent progress in research by IUFRO's Special Programme for Developing Countries, as well as that conducted under the aegis of ITTO, which has a special mandate for commercial forestry activities;

(iv) enthusiastic endorsement should be given to the recommendations of the Task Force for increasing the flow of resources to forestry research worldwide, especially for strengthening national institutions. These recommendations were fully supported by all the donors assembled at Bellagio II;

(v) there were both national and international dimensions of the research activities advocated by the Task Force. There was a unanimous expression of concern that direct and early attention be paid to the research needs of national organizations engaged in agricultural and forestry research. Institutions need strengthening; existing technologies and research knowledge needs to be disseminated to practitioners, whether commercial foresters, forest managers or farmers through programmes of agroforestry, social or industrial forestry. The meeting was particularly concerned to improve the capability of these institutions by supporting the quality and numbers of their manpower;

(vi) the Task Force presentation had indicated there is a substantial research knowledge in the field of forestry which needs wider dissemination. It urged early action to disseminate present research results through national systems and agencies concerned with global forestry;

(vii) the five priority research areas presented by the Task Force were endorsed. The meeting recommended moving forward speedily on two of the areas outlined, and a component of the third.

(a) As an initial measure, the CGIAR and some of its associated institutions will be requested to begin plans for work on agroforestry and watershed management. These are appropriate components, for example, for IITA and CIAT in the associated CG centres or for ICRAF in the non-associated centres. ILCA, as an associated CG centre, will also be requested to undertake further work in these areas. At the same time vigorous action will be taken to collaborate with the World Wildlife Fund, IUCN and other conservation agencies to intensify research into conservation and biological diversity.

(b) IFPRI will be asked to join other institutions already working on the policy and socio-economic aspects of forestry.

(c) Although the Task Force had not addressed itself in specific terms to the issue of genetic resources, it was felt the IBPGR should be asked to consider adding to its remit the collection of germ-plasm of important commercial tree species. Several centres concerned with agroforestry will be asked to work with foresters in the process of selection of tree species which should be quickly moved into the hands of smallholders, farmers and others concerned with tree propagation. This would be the third area of research identified by the Task Force.

(viii) after examination of the five options presented by the Task Force, the meeting endorsed Option 1 in the immediate term, which is fundamentally "no change". It took this course because in the immediate future it did not wish any
diminution in action or in the flow of resources while the meeting’s recommendations are being implemented. The relative cost implications of a donor co-ordinated group that would ensure longer-term support for forestry research will now be examined in greater detail. Particular attention will be given to Option 5, which is the present CGIAR, with a separate Technical Advisory Committee for forestry. The meeting was attracted to Option 5 because it would not involve splitting forestry research activities. It was considered necessary to co-ordinate research into the problems of agroforestry with those activities that affect broader issues of natural forest management and wood utilization, which are normally administered by forestry agencies. The latter activities have important implications for commercial forestry. All aspects of forestry research need to be integrated, including agroforestry, social forestry at the village and farm level, through to the issue of forest land management which may impinge on the preservation of bio-diversity in wilderness areas. The same applies to the use of forest land for commercial purposes.

3. The meeting endorsed the Task Force’s recommendation that an entity be created with the responsibility for co-ordinating forestry research as a whole. The preferred Option 5 would be an expansion, probably involving a change of name (certainly a change of meeting pattern), for the CGIAR. The CG would need to be reconvened at its annual meeting as a CG concerned with both agriculture and forestry. The forestry aspects would, however, be guided by a separate TAC. The meeting recommended that the above proposals be costed. The co-sponsors of Bellagio II, the Rockefeller Foundation, UNDP, the World Bank and FAO, have agreed to undertake this task and to submit a paper to donors by the end of January/early February 1989. The paper will be reviewed by donors participating in Bellagio II and then considered by the CG meeting in Canberra in May 1989. The meeting hopes the CG will then endorse the early changes necessary to establish a forestry TAC and examine the need for a restructured CGIAR secretariat.

4. The Task Force was commended for providing an extraordinarily useful document including the background papers.

5. Finally, the meeting agreed on the need for another Bellagio meeting to review progress being made on all the conclusions of Bellagio I. Every effort must be made to keep forestry at the forefront of the development agenda.

Agreed at Wiston House
1 December 1988

The Bellagio Meeting on Tropical Forestry Research was convened under the auspices of:

- The Rockefeller Foundation
- United Nations Development Programme
- The World Bank
- Food and Agriculture Organization of the United Nations.

The Association’s New Zealand House Queen’s Award Dinner in London

A major initiative by Vice President Christopher Latham to support the Queen’s Award for Forestry was launched with the UK based timber trade at New Zealand House on the 27 September. The use of the penthouse on the 17th floor of New Zealand House was organised and funded through the good offices of NZFP Pulp and Paper Ltd.
The Guest of Honour was His Excellency Bryce Harland, the High Commissioner for New Zealand. The Australian High Commission was represented by the Honourable Richard Starr and Canadian goodwill was demonstrated by Noranda and the United Kingdom Forestry Commission was represented by its Chairman, Sir David Montgomery.

The supporting team from the Association was headed by His Grace, our President, with the Chairman, Roger Bradley, Vice-chairman Bob Newman from Tasmania and most of our Vice Presidents who are past chairmen of the Association. Other members included several with established interests in the timber trade and the balance from the timber industry found many faces of known friends.

The thrust of the Queen's Award for Forestry appeal was delivered by Ron Groves Meyer International with supporting information in literature and copies of the June Review.

It is hoped that the Appeal would raise a capital sum which would provide periodic Awards from the interest. At present the support received as a result of the Dinner and from Association members would be able to provide three awards from capital so it is hoped that contributions will continue to arrive to enable the fund to accumulate.

The Second Queen's Award for Forestry will be presented at the 13th Commonwealth Forestry Conference Banquet on the 20 September, 1989 at Rotorua, New Zealand.
September '88 meeting of the Association

Following the morning Executive meeting on the 29 September, 1988, additional members, wives of members and our President gathered for a light lunch in the centre of the New Forest in Hampshire, U.K. The Deputy Surveyor of the Forest, David Perry, conducted the party from the Bramble Hill Hotel through Fritham past Cadman's Pool, Bolderwood, Burley Lodge to a final stop at the Forest Tea House. The 2½ hour tour, with stops to demonstrate the wide range of interests, which exercise the Commission's management of the forest, offered a flavour of the area. Members made their own arrangements to explore further portions of the forest.

The party enjoying lunch al fresco at Bramble Hill.

The Assistant Secretary flanked by the Treasurer and past chairman John Brazier with the Secretary and 'Dick' Richards.
Annual Meeting 1989

The 1989 Annual meeting will be held in Scotland, in Dumfriesshire, at Drumlanrig Castle by the kind invitation of our President, His Grace, The Duke of Buccleuch and Queensberry. The formal meeting will be held at noon on Thursday 25, May and will be preceded by a meeting of the Executive and Governing Council at 10.15 am. Following lunch, in the castle, members and friends will have the opportunity of seeing some of the estate's extensive woodland before returning for tea and the offer of a visit around the castle. The present building is 1679-91 and is superimposed upon the 14th and 15th century strongholds of the Douglases; the lands in Nithsdale being the rewards to the family for their staunch support to King Robert Bruce. The Association's Dinner will be held in the evening at Mennockfoot Hotel, by Sanquhar.

Our hosts for the morning of the 26, May are the staff of the Forestry Commission involved with the Forest of Ae, just to the north east of Dumfries. After a welcome at the Management Training Centre, the party will embus for the climb to the plateau with various stops to experience something of this 13,000 ha conifer forest. Our destination after lunch is the nearby modern softwood sawmill of James Jones. In addition to showing us around the plant, the Company will show, with converted lumber, the comparative reduction in yield which is associated with asymmetry in the log. Some refreshment has been offered before we disperse.

13th Commonwealth Forestry Conference

The Conference is being hosted by the New Zealand Government through the Ministry of Forestry and will be based at Rotorua, North Island, from the 17-30 September, 1989. A handbook for the conference is obtainable from The Secretary General, Alan Familton, Ministry of Forestry, PO Box 1610, Wellington, New Zealand.
Pre-conference tours to the sub-tropical region of Northland or to the Coromandel Peninsula will be arranged by the Conference travel agency on a group or individual basis. International airports are Wellington, Christchurch and Auckland, the latter being the most convenient for Rotorua. Transport from Rotorua airport to hotels and motels is being arranged by the Conference travel agency (Galaxy C P) from Friday 15 to Monday 18 September; return on 29 and 30 September.

Post-conference tour departs from Wellington early on Monday, 2 October and terminates in Christchurch late on Wednesday 4 October.

Brief Conference programme:-

September
17 registration at Hyatt Kingsgate Hotel 11-5pm. Maori welcome 7-9pm.
18 opening ceremonies, theme address, photo, country and agency reports.
   Evening function hosted by the New Zealand Government.
19 regional reports continued.
   Evening (7.30pm) **Commonwealth Forestry Association Meeting**.
20 technical innovation — what's new in soil and water management, tree improvement, disease and pest control, remote sensing, information technology.
   Conference Banquet. **Queen’s Award Presentation**.
21 field trips — forest nursery, genetics, tissue culture, commercial reforestation and silviculture, log harvesting and transport.
   or Lake Taupo Forest and a joint afforestation project between the Maori landowners and New Zealand Forest Service initiated in 1960s.
   or Whirinaki Forest Tour, a State Forest Park with a history of partial logging and regeneration now under the management of the Department of Conservation.
22 valuation of forestry benefits, large and small scale timber enterprises, as a source of edible materials and minor produce, wildlife, conservation and habitat protection, agroforestry.
23 continuation of previous day's theme based upon tourism, recreation, watershed protection, soil fertility and climatic stability. The Forest Research Institute will be open after lunch, an evening programme of entertainment is being organised.
24 free day.
25 accountability, legal, multiple use, investment appraisal, cost benefit, investment appraisal for corporate investment.
   A general meeting of the I.U.S.F. in the evening.
26 continuation on the previous day’s theme. Delegates select one of three groups for the afternoon — people — education and research or valuation procedures, harvesting and plantation management in the tropics and a corporate approach to multiple-use forest resource management.
   **Commonwealth Forestry Association Reception** in the evening.
27 Commonwealth initiatives on the Tropical Forest Action Plan. The choice for the afternoon will be between case study presentation and group discussion on the TFAP or Temperate Plantation Management — tree breeding, silviculture harvesting and logging.
   The New Zealand Industry will sponsor a cocktail party in the evening.
28 group discussions with an option of short field trips after lunch.
Conference conclusions and recommendations.

adoption of recommendations, closing ceremonies.

The journey, for those attending the post conference tour, is either 6 hours by road or 70 minutes by air. The official airline carrier is Air New Zealand.

There is an interesting programme for those accompanying delegates of the conference. Enquiries concerning registration, travel within New Zealand and for accommodation should be directed to Ms Sue Hatchwell, Galaxy Convention Planners, PO Box 2149 Rotorua, New Zealand.

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SOLOMON ISLANDS

The Solomon Islands are a Melanesian archipelago in the South-West Pacific Ocean. Timber exports are vital to the country's economy and an intensive research programme is currently under way to improve the management of commercial forest plantations.

Silvicultural Research Officer

Based on the island of New Georgia and travelling extensively, you will advise the Ministry of Natural Resources on research into a wide range of topics such as forest pathology and entomology. You will also have the opportunity to lead research in key areas such as species performance in relation to altitude and techniques of plant production and plantation management.

QUALIFICATIONS

Applicants should be British Citizens with a degree in forestry and a minimum of 3 years' post qualification experience in tropical hardwood and silvicultural research. A postgraduate qualification and experience of computers will be an advantage.

Silviculturalist

Based in Kolombangara, your research will be aimed at the development of commercially oriented silviculture for Kolombangara Forest Products Ltd (KFP). The principal lines of research will be for the major project species, initially gmelina, eucalyptus and teak. The work will cover areas such as general silvicultural techniques, nursery techniques, vegetation propagation, suitability for high elevation sites and the monitoring of pests and diseases in KFP plantations.

QUALIFICATIONS

Applicants should be British Citizens with a degree in forestry. Experience in tropical silviculture is essential, while experience in planning, conduct and analysis of silvicultural research investigations is desirable.

TERMS OF APPOINTMENT

Both posts are on contract to the British Government and on loan to the Government of the Solomon Islands for a period of 2 years. Salaries will be in the range £21,575 pa to £28,625 pa (UK taxable) together with variable overseas allowances currently of £3,358 pa (single) and up to £5,608 pa (married). Benefits include children's education allowances (there are no suitable educational facilities on New Georgia and Kolombangara for expatriate children), free accommodation, passages and fare paid leave after one year.

For details and application form, please write, quoting the job title and reference number 369/EC/CFJ to: Appointments Officer, Overseas Development Administration, AH220, Abercrombie House, Eaglesham Road, EAST KILBRIDE, Glasgow G75 8EA. Or tel: 03552 41199 ext 3314.

When replying to this advertisement, please mention the Commonwealth Forestry Review.
Eucalypts gain in popularity with the farmers

In January, 1984 there was an orchestrated attack on the planting of Eucalypts in an important Delhi based paper. Captioned “Eucalyptus Culture Hurts Farmers” it was related that in the State of Karnataka, 1M seedlings of eucalypts had been uprooted by angry farmers who claimed that the government sponsored planting of the eucalypts was lowering the water table. The Farmers’ Association asked the Forest Department to suspend eucalypt planting. Although the adverse claims against the species were disputed by the Forest Research Institute at Dehra Dun, various management bodies and environmentalists unleashed a tirade of abuse against this ‘exotic’ species.

Government apathy followed the media criticism but Forest Departments retained their enthusiasm. The merits of eucalypts as a commercial species on farmland have been advocated at seminars and conferences. Farmers have come to appreciate the comparatively low establishment cost, the species' vigorous powers of coppicing and its speed of growth under hostile ecological conditions.

The same paper published on the 14 August, 1988 a news item headed ‘Most Afforestation on Farm Lands’. Assessments of planting over the period from 1983-87 showed that inspite of the hue and cry about Eucalyptus, this was the most important species chosen for the farms. The figures for the eucalypt planting showed the percentages to be 81% for Gujerat, 76% for Karnatak, up to 42% in Tamilnadu accompanied by 20% for acacias and 14% for Casuarina and for the State of Uttar Pradesh, the eucalypts represented 94% of the seedlings used.

Your readers may be interested to see that Indian farmers are gaining in confidence in the benefits which eucalypt planting will bring and are prepared to refute the whims of the media based band waggon.

Yours truly,

B. L. Das (Retired, Chief Conservator of Forests, Orissa)
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NEWS OF MEMBERS AND FRIENDS

Dr. Lex Blakey is sent good wishes for his retirement announced earlier in the year. He had served CSIRO for 36 years and was Chief of the Division of Building Research. This Division has been merged with the Division of Energy Technology to form the Division of Construction and Engineering. Dr. Blakey’s first appointment with CSIRO was as head of Structures and Concrete Technology following his engineering degree at West Australia and PhD at Cambridge. He fostered the formation of the Australian Building Systems Appraisal Council.

Dr. John Brazier has succeeded Jean Taylor as the President of the Institute of Wood Science.

Jean Brook is a recreation reserve, complete with pine seed orchard, a large hut and bubbling stream in the Black Buff Range of North West Tasmania.

Dr. Andrew D. Cameron has returned to the University of Aberdeen from the Forestry Commission. His forest nursery interest developed from his clonal and tissue culture work with birch and Scots pine for his PhD. He will be teaching silviculture and will be involved with practical training.

Graham Chaplin has returned to the UK from the Solomon Islands and whilst awaiting his next appointment is carrying out Camellia spp. assessments at the OFI. The work in the Solomon Islands will be continued by Anthony Fraser who was recently working in Tanzania.

Gilles de Chatelperron has been seconded by the French Government as an associate expert to ICRAF. His responsibilities will include the acquisition and dissemination of agroforestry information with francophone institutions. the acronym ICRAF (International Council for Research in Agroforestry) will now be used on french translations although the organisation will still be known in French as — Conseil international pour la recherche en agroforesterie.

Pol Coppin has commenced work for his PhD at the Forest Resources Assessment Section of the University of Minnesota. The remote sensing Forest Inventory Programme is sponsored by NASA.

Robin Cutler has been appointed Acting Secretary of Forestry for the New Zealand Ministry of Forestry. This follows former Secretary Dr. Russ Ballard’s appointment as Director General of Education. Mr. Cutler’s previous responsibilities for consultancy, protection and information services will now be covered by Mr. John Handiside. He will retain his responsibilities as Regional Manager for Nelson.

Gael Davidson has returned to Australia after a year in Ecuador where work included involvement with the Tobar Donoso project. The Ecuador Government had declared an ‘Ethnic Forest Reserve’ of 130,000 ha and in May, 1988 added a further 100,000 ha buffer zone. The Awa indians have established a 150 mile strip to demarcate the Ecuadorian margin of their forest homeland which spreads across to the Choco Refugia in northern Colombia. Under Ecuador’s land reform laws any ‘unproductive’ land is available for colonization. Hence if the demarcation of the boundary is not to be lost under regrowth, the strip needs to be planted with fruit and other recognisable exotic timber species. Further details may be obtained from Douglas Ferguson, C/o Casilla 344-A, Ulloa y Ramiro.
Davilos, Quito, Ecuador. Meanwhile, Gael, at 3 Gingin Rd., Lancelin 6044, Western Australia is seeking funding to participate in some similar project.

Stephen Fairburn, Assistant Manager at the Harcross depot at Pickering in England, has won the 1988 TRADA prize for the Institute of Wood Science. The presentation of his certificate and a cheque for £50 was made by Christopher Latham, a past president of the IWSc.

Michael Gane has been acting as the FAO team leading consultant in Nepal. Some details of the Plan for the next 22 years appear in the ‘Around the World’ section. The executive summary of the Plan is available on request from Rabi Bista, MPFD Project, Ministry of Forests and Soil Conservation, Kathmandu, Nepal.

Humberto Soriano Garach obtained his forestry degree in Honduras in 1976 with further qualifications from the University in Managua, Nicaragua and the Swedish Forest Management Course at Umea. He has managed tropical pine plantations, tropical logging operations and had three years as Chief of the Forest Resources Assessment Unit. He is living at 175 Emerson Avenue, Toronto, Ontario, M6H 3T4 in Canada and is hoping that a reader of the Review can suggest an appropriate employment for his talents.

Patrick Hardcastle, who graduated from Aberdeen in 1968, worked in Malawi forest management and as head of the Forest Research Institute, he has joined the teaching staff of the Forestry Department at Aberdeen. He obtained his MSc from the University of Malawi and an MBA from the University of Edinburgh. Since 1981 he has been course organiser for the Specialist Forestry Courses at Oxford. The Association's appreciation for the time that Pat has been the CFA honorary treasurer was expressed at the September meeting of the Executive.

Dr. George Holmes has been nominated to join the Board of Trustees of ICRAF. Since his retirement as Director General of the UK Forestry Commission his occupations have included being Chairman of the Rockefeller Foundation's Bellagio Task Force for Tropical Forestry Research.

Frank Knight has taken up a post with Mondi Forests, Peak Timbers Ltd., PO Box 3, Pigg's Peak, Swaziland having handed over his office in Zimbabwe to A. R. Hulett — both of them being graduates of UCNW.

Dr. Barbara H. Knowles is one of 31 recipients of Royal Society Fellowships. She is holding her Fellowship at Cambridge studying how the toxins produced by Bacillus thuringiensis act on their target tissues.

James Mackenzie visited the office in Oxford on his way, via Ibadan in Nigeria, to the National Tree Seed Project for ODA in Nepal. He last met the Secretary with Mike Coutts and Mick Scott in the West African Regional finals of the John Holt Bowl.

Terence Mallinson at Yokohama spoke on behalf of the Timber Trades Associations of the European Community to the seminar of the International Tropical Timber Organisation. The suggestion is that funds raised by the imposition of a surcharge on all imports of tropical timber should be channeled through the ITTO to assist the producing countries to so manage their forests that yields of tropical timber may be sustained. The September meeting of the Timber Trade Federation at the Royal Commonwealth Society hoped that the annual funds would be about US $ 30M.
Dr. S. D. Richardson will be acting as consultant for the FAO in Papua New Guinea in association with the implementation of the Tropical Forestry Action Plan. Assistance for the Plan has been offered by the Asian Development Bank, GTZ, IIEC, IUCN, Japan, UNDP and the World Bank.

Major Michael Strang Steel has been appointed a part-time Commissioner for the UK Forestry Commission. He manages the family estate at Philiphaugh, Selkirk and is a Vice-Convener of the Scottish Landowners’ Federation.

George Taylor has retired as Conservator for South Scotland for the Forestry Commission and has joined the Forestry Department at Aberdeen where in addition to his special responsibility for developing practical training his other courses will include the management of forests for sport.

Brian Wall, President of the New Zealand Forest Owners’ Association from 1981-86 has joined Tilling Timber Pty Ltd. in Victoria, Australia. He joined the family sawmilling business in 1957, worked in senior management in Canada and the USA and more recently for 14 years with the Nelson based Baigent Forest Industries Ltd.
VALEDICTION

The following verses were part of the farewell to Dr. H. Colyer Dawkins on his retirement from the Oxford Forestry Institute. Any similarity to earlier publications in the Review may be assumed to be a simple case of plagiarism.

He aims to be the model of the knobble-kneed Conservator
He has incremental dope about paraboloids and curvature,
With Smythies and von Mantel he can cook the possibility
And diagnose a deficit of water with facility;

The complicated vagaries of selenoid photometers
In correlated periods with permanent dendrometers
Are interdigitated with his diurnal activities
And well within the scope of his silvicolous abilities;

And when he learns how seedlings can be bedded in a nursery,
How axes may be sharpened with the minimum of cursery,
And when he sees how calculating area’s not a mystery,
Then he’ll certainly be top elite Conservator of Forestry!

He has studied every subject and sampled every ology
The geo- pedo- physio- and pseudo-speicology,
Reciting all the species of the mosses and Hepaticae
Is simple as determining the Algae and Agaricae.

The heterozygosity of polyploidal Glyptostrobes
He frequently elucidates with Pressler’s sort of xyloprobes,
His competence phenomenal at graminoid agronomy
Will manufacture peelerwood from lalang with economy.

So when he learns how climber-cutting liquidates the ropiary;
And ecualypt is not a term for australiasian topiary;
And when at last he finds a real compartment and its history,
Then he’ll surely stand a chance to be Conservator of Forestry!

He easily distinguishes phylloclads from phototaxis
And can treat a young bostrychid with malarial prophylaxis,
When you find that all the tracheids are embedded in parenchyma
He’ll help you disentangle it and tell you its sclerenchyma.

In ignorance of rings or age or any guess at height at all
He’ll give you data accurate on volume of the crop an’ all;
Statistical and mystical and utterly reliable
He’ll even prove that fossil seeds are definitely viable.

But when he learnt that abaci weren’t worked by electricity
That bits and bytes are not a gastronomical felicity
And when he thought of CCU without any duplicity
Then they had to make him lecturer in Forestry Biometry.
OBITUARY

Jack C. Westoby CMG

Though Jack Westoby came to forestry relatively late in his career, over a period of more than two decades he was one of the most influential voices in international forestry.

Born and educated in Hull, he worked as a railway official for nine years before joining the Board of Trade as a statistician in 1945. While responsible for coverage of the timber trade, he was sent to a meeting in Geneva of the ECE/FAO Timber Committee at a time when that body was working on the first European Timber Trends Study. His contributions at that meeting led to an invitation to join the secretariat engaged on the study, which he did in 1952.

In 1958 he moved to Rome, to become Chief of FAO’s Forest Economics Branch. There he directed the extension of the cycle of trends studies to the other regions, culminating in the global study which FAO presented at the Sixth World Forestry Congress in 1966.

It was during this period that he also published his seminal 1962 paper on the role of forestry in the process of development. He was to continue to explore this relationship throughout the rest of his life; always seeking to make forestry more effectively responsive to human needs. Few who heard it, or who have read it (CFR 58:2), will have forgotten his memorable address on the subject to the Eighth World Forestry Congress.

This aspect of his work reflected Jack’s abiding concern with the impact of forestry on people. His oft quoted comment to the effect that forestry is about people, not trees comes from a paper that long predates “social” forestry. This also underlay his continuing advocacy of the importance of having a well formulated and entrenched forest policy — a subject about which he was corresponding in the CFR with his accustomed vigour and clarity as recently as 1986.

Appointed Deputy Director of FAO’s Forestry and Forest Industries Division in 1962, and Director, Programme Coordination and Operations, in the newly created Forestry Department in 1968, he did much to give shape both to the direction of forestry assistance and to development of the sector in individual countries where FAO was active. Among the many honours conferred on him in recognition of his contributions to international forestry during this period was that of CMG.

In 1974 he left FAO, in order to be able to devote more time in his writing, and to speaking and teaching engagements. This period saw some of his most memorable work, the best of which was brought together in a 1987 book, “Making Trees Serve People” (Blackwell, 1987).

Jack’s interest in people equally permeated his personal life. Over the years he and Flo, his wife, were the focal point for an ever growing body of friends and colleagues, to whom he was a constant source of inspiration and encouragement. Though increasingly hampered by ill health, he remained determinedly active intellectually, completing a second book, “An introduction to World Forestry”, just before he died. Intended to help young people entering forestry to understand its role, it is good to know that in this way his unique contribution to the profession will continue to be available to those working in it in the future.

J. E. Mike Arnold
NEW PUBLICATIONS
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During the past 60 years, perhaps ten million trees from some 215 species have been planted in about thirty projects in Somalia. Names and locations of past and present organisations involved in planting are listed in this study, which finds there has been excessive optimism as to what species, especially exotics, will grow successfully. While it is premature to make firm species recommendations for the different Somali ecological zones, the most promising are identified.


In 1988 the National Hardwoods Programme joined with the Uneven-aged Silviculture Group for a combined meeting, from which some seven papers are presented here. The meeting focussed on three themes: the conversion of broadleaved high forest containing ash, birch, cherry and sycamore as well as beech and oak into productive stands using systems of uneven-aged silviculture; the need for a policy for the expansion of broadleaved forestry; and the need to make the best examples of hardwood silviculture more widely known and available for study.


Seven papers presented at the 1988 BAAS meeting, dealing with trees in support of agriculture; rural policies in the EEC; educating agri-foresters; changing land use in the lowlands; perceptions of the rural landscape; social benefits of planned use; and the harvesting, marketing and production implications of the storm of October 1987.

Available from:
Library and Information Service
Oxford Forestry Institute and
Department of Plant Sciences
South Parks Road
OXFORD OX1 3RB, U.K.

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LANE, I.R., Lower Kenfield Cottage, Petham, Canterbury, Kent CT4 5RN
LEWIS, J.B., Managing Director, Schauman (UK) Ltd., Stags End House,
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**Associate**
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GREENWAY, K.J., 10946-88 Av., Edmonton, Alberta, T6G 0Z1, Canada
LEEGER, B., William Carey International University, 1539 E. Howard Street,
           Pasadena, CA 91104, U.S.A.
MANJUNATH, A., Department of Forestry, Univ. of Agricultural Sciences,
           Bangalore 560 065, India
PADMANABHAM, P.V., Divisional Forest Officer, Ramaraopet, Kakinada, 533 004
           India
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The course comprises three major areas of study:

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2. **Management** – this comprises 25 per cent of the course with major study areas of communication, people and organisation, management processes, planning and control and marketing.

3. **Specialisation Module** – tuition with a strong tutorial input is aimed at developing specialist knowledge as the course progresses; it culminates in the submission of a major dissertation which combines technical, managerial and financial aspects; options include the following:
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   - Drying
   - Preservation
   - Wood-based panels
   - Utilisation/marketing of wood products
   - Timber construction/engineering
   - Furniture production
   - Wood machining
   - Timber trades practice/economics

The next course commences September 1989

Further details and application forms may be obtained from:

Abel Comben, The Course Director:
Diploma in Timber Studies,
Department of Timber and Materials Technology,
Buckinghamshire College of Higher Education,
Queen Alexandra Road, High Wycombe,
HP11 2JZ, Bucks, UK.
Telephone (0494) 22141 Ext. 258 Telex: c/o TRADA 83292 Fax: (UK) (0494) 24392

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## FORTHCOMING INTERNATIONAL DATES

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<tr>
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<tr>
<td>17/2/89-27/2/89</td>
<td>GHANA, Accra. GIFEX '89 Ghana Timber. Ref: Kwame Boakye, Ghana Furniture Producers Association, PO Box 32, Trade Fair Centre, Ghana.</td>
</tr>
<tr>
<td>25/5/89-26/5/89</td>
<td>SCOTLAND, Dumfriesshire. Commonwealth Forestry AGM and Excursion. Ref: The Secretary, CFA, OFI, South Parks Rd., Oxford OX1 3RB.</td>
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<tr>
<td>27/6/89-1/7/89</td>
<td>MALAYSIA, Kuala Lumpur. Woodwork 89 (Forestry, Timber Processing, Woodworking Exhib.). Ref: Randle Theobald, O.E.S. Ltd., 11 Manchester Square, London W1M 5AB, UK.</td>
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<td>10/7/89-14/7/89</td>
<td>TRINIDAD AND TOBAGO, Port of Spain. International...</td>
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Conference: Leucaena in Agricultural Development.
Ref: G. Garcia, c/o Dept. of Crop Science, University of the West Indies, St Augustine, Republic of Trinidad and Tobago, West Indies.

23/ 7/89-26/ 7/89 USA, Boston. Meeting Global Wildfire Challenges (International).
Ref: National Fires Protection Association, Batterymarsh Park, Quincy, Massachusetts02269, USA.

24/ 7/89-29/ 7/89 SCOTLAND, Edinburgh. International Conference of Agroforestry (IUFRO).
Ref: Agroforestry Conference, Dept. of Forestry and NR, University of Edinburgh, Mayfield Road, Edinburgh EH9 3JU.

Ref: G. B. Walford, Forest Research Bag, Rotorua, NZ.

15/ 9/89-17/ 9/89 CANADA, Montreal and Toronto. Woodworking and Machinery Trade Fair.

18/ 9/89-24/ 9/89 ITALY, Cansiglio. Mountain Silviculture in the Southern Alps. IUFRO S1.01-02 and S1.05-08 excursion.
Ref: Prof. Pietro Piussi, Instituto di Selvicoltura, Via San Bonaventura 13, 50145, Firenze, Italy.

18/ 9/89-29/ 9/89 NEW ZEALAND, Rotorua. XIII Commonwealth Forestry Conference, preceded by tour in North Island, post conference tour in South Island.

Ref: Professor Dr. H. Zöhl, Albert Ludwigs Universitat Institute, Bertoldstrasse 17, D-7800 Freiburg.


Ref: Dr. Klaus Johann, Förstliche Bunderversuchsanstalt, Vienna, Austria.

19/ 9/89-21/ 9/89 ENGLAND, Oxford. Arboricultural Association. 25th AGM.
Ref: Ampfield House, Romsey, Hants SO51 9PA (Not 1988!).

Ref: H. F. Kaiser, USDA Forest Service, PO Box 96090, Washington D.C. 20090-6090, USA.

Ref: Jennifer Pok, Singapore E.S. Pte., 11 Dhoby Ghaut 15-09 Cathay Building, Singapore 0922.

2/10/89- 6/10/89 GERMANY FR, Friedrichshafen. Int. Conference on Forest Decline Research.
FORTHCOMING INTERNATIONAL DATES

Ref: Interplan Congress Office, Sophienstrasse 1, D-8000 München 2, Federal Republic of Germany.

15/10/89-20/10/89 AUSTRALIA, Perth. 13th All Australia Timber Congress. Strategies for Growth.
Ref: Secretariat 13th AATC, POB 411, West Perth, West Australia 6005.

22/11/89-24/11/89 CUBA, Havana. 1st Cuban Forestry Conference.
Ref: Instituto de Investigaciones Forestales calle 174, No 1723 entre 17-By 17-c Siboney, Zona Postal 16, La Habana, Cuba.

Ref: Deutsche Landwirtschafts-Gesellschaft, Zimmerweg 16, 6000 Frankfurt am Main 1, F.G.R.

Ref: Profile Publishing, Auckland, New Zealand.

Ref: Nathalie Geraud, French Trade Exhib., 197 Knightsbridge House, Knightsbridge, London SW7 1RB.

3/7/90-8/7/90 GERMANY, Munich. INTERFORST 90 Trade Fair.
Ref: Münchener Messe-und Ausstellungsgesellschaft mbH, Messegelände, Postfach 1210 09, D-8000 München 12.

Ref: IUFRO Montreal 1990 Inc., Box/C.P.1990, Place d’Armes, Montreal, Quebec, Canada H2Y 3L9.
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AROUND THE WORLD

CHILE

One version of Chilean Forest News is published in English. The August, 1988 issue gives the timber export figures for the first half of 1988. The total, for the half year, of US $361M shows an increase of 46.7% over the corresponding period for 1987. This increase reflects extra quantities as well as improved prices. The list of forest produce includes 230 different categories; squared Pinus radiata timber increased by 47.9%, unbleached pulp by 35.35%, veneer by 27.76% and newsprint by 27.57%. The export weight of over 2.25MT showed a 24.6% increase. The main exports ‘in terms of value and volume’ were bleached pulp 25.1%, unbleached 14.7%, sawn radiata 13.4%, radiata logs 12.6% and newsprint 10.2%. Exports went to 53 countries, Asia taking 30% — with Japan in the lead, Europe taking 30% — with Federal Germany taking 7.9% and other South American countries taking 25%. One of the figures of note that will appear for the second half of 1988 is the shipment of 22,000m3 of eucalyptus pulpwood logs to India.

It is hoped that foresters who receive adverse publicity for advocating the use of exotic species can use the example of Chile and New Zealand where the bulk of the wealth and export revenue is founded upon the use of non native timbers. Chilean foresters are now inoculating soils with Botetus edulis to enjoy both the enhanced growth from the mycorrhizal association on the growth of their Pinus radiata and with a view to the marketing of the fungi. Chile has an established fungi market in Germany, a country which already accepts the same B. edulis from the introduced pine and fungi from South Africa.

CHINA

Regional Forestry Officer Y. S. Rao has kindly forwarded an article from the Ministry of Forests in Beijing which reflects some of the same sources as H. G. Lai’s paper in the 200th issue of the Review and C. K. J. Lee in CFR (65(1), 1986 but the figures warrant this further digest.

In 1978 the national percentage of forest cover was 4%. Forest cover was still being lost with new establishment only compensating for half of the lost area. The projects which have since been implemented and will be completed by 1996 will increase the forest area to 7.7%. Arid or semi-arid deserts cover 4Mkm², 41% the land and over a recent span of 25 years, a further 3.9Mha have been adversely affected by desert expansion. Shelter belts delay desert expansion and enhance the opportunities for agriculture. The benefits from the belts can be a reduction in windspeed by 30-40%, an increase in relative humidity by 10-20%, a decrease in evaporation by 29%, an increase in soil moisture by 20-30% with the resulting decrease in the risk of sandstorms and hot dry winds. Additional areas can be brought under agriculture and the improvement on established farm land can be the production of an extra 15T of biomass to the hectare. Between 1978 and 1985, 6.05Mha were planted with belts, protecting 8Mha of farmland and 1.7Mha of pasture.

Vegetation and forest cover has long been appreciated in mountainous regions, 2.6Mha had been ‘protected’ by 1952, 890,000 ha is mentioned as being closed for natural regeneration by 1985, with the 1986 ‘protected’ figures being 23.8Mha. By 1996, some 9.45Mha will be enclosed and the chance of regeneration will be enhanced through aerial seeding.

The range of various habitats which exist over China provide the homes for 2,400 animal species and 30,000 plant species and include one seventh of all the internationally
listed species under threat of extinction. The 40 Nature Reserves established by the
1950's had increased to 133 by 1984, covering 8.06Mha and 333 by 1986 — at 19.33Mha
and it is intended that by 2000 there will be 494 covering 2.5% of the land.

The coastal regions have also been protected with shelter belt planting. Some
3.33Mha have had their shelter improved, mitigating the worst effects of typhoons, flood
and drought since 1949.

Utilization of forest produce is planned to offer a sustainable resource. Sawn timber
from the State forests has increased from 3.44Mm³ in 1950 to 15.9Mm³ in 1985; wood
based panels have increased in volume from 16,900m³ in 1951 to 1.65Mm³ in 1985. State
help to forestry co-operatives has helped boost timber production from 6.64Mm³ in 1980
to 60Mm³ in 1985 and has shown 175% return on the investment. Minor forest produce
has increased 36 fold since 1957 and eightfold since 1978. Individual items mentioned
include 2,400T of honey, 160T of edible black fungi, 80,000T of cereal, 0.55MT of
vegetables, 317,000T of oil — some 4Mha of tea oil is producing 0.5MT of oil seed which
provides 30-50% of the vegetable oil consumption in the south of the country. Tree seed
figures include for 1983, 119,000T of walnuts, 65,000T of chestnuts and 0.35MT of dates.
Specialised establishment features 2Mha of fuelwood planting between 1981 and 1985,
15,000ha for pitprops, 80,000ha for raw material for paper making.

Rural communities have planted 1,500M trees around villages, along roads and
canals. Town planting involves 100M trees a year and on Tree Planting day, some 200M
able bodied people each plant their five trees. The schools have established 0.3Mha of
forest farms, the army has planted 110M trees around their camps and tackles an annual
barren land planting of 44,000ha.

The area of waste land with a potential for forestry and animal husbandry in 1949 was
assessed at 289Mha. By the mid 1980’s 51Mha had been brought under management.

**CYPRUS**

The Director of the Department of Forests, Leontios I. Leontiades, has kindly
forwarded the Annual Report for 1987 from which the following highlights have been
selected.

The forest estate increased during the year by 21ha to a total of 1,602 km². The cost of
running the Department was just over £2M, direct revenue brought in just under £1M.
The State Forests produced 52,169m³ of timber (of which 3,860m³ was branchwood) and
further equivalent of 15,400m³ of firewood. Private forests produced 1,904m³ of timber
and the recorded figure of 1,000m³ equivalent of firewood. The Country is a net importer
of timber and timber products, the cost of imports being in the region of £24.5M. The
State Forest sustained some 320 people including casual labour and those on contract
work. The timber industry includes 297 sawmills, match and parquet floor
manufacturing and other minor forest industries provide occupation for a further 6,230
people.

Fire has long been a major concern on the island. Readers of Jack Thirgood’s book
will be pleased to note that in the 1980’s the Forest Deparment can write ‘malicious forest
fires are fortunately non existent in Cyprus’. Forest fire loss for the worst ten years
selected from the last hundred average around 41,000ha with the peak during the
fighting of 1974 at 193,000ha. The best ten years average at about 30ha: 1986 was 467ha
and 1987, 96ha.

The forests play an important role in tourism which justifies some expense in road
construction, the provision of camping sites and nature trails. Flocks of Moufflon are
prospering. Sheep and goats permitted number 5,524. Wildlife which is not welcome
includes the processoriany caterpillar, *(Thaumetrpoea wilkinsoni)*. This has been
treated from the air and ground with *Bacillus thurigiensis* which controls the unwanted host without an adverse effect elsewhere.

Just under half a million plants were issued from the 800,000 raised in nurseries. Reforestation covered 640ha with some 17 bulldozers assisting with the terracing seen in the report's photographs. Species mentioned include *Eucalyptus* and *Pinus* with an F 1 hybrid between *P. brutia* and *P. halepensis* showing promise.

The Forestry College was in its 37th year and is attracting students from at least 14 countries and four continents.

**NEPAL**

The Master Plan for the Forestry Sector of Nepal has been prepared by the Government of Nepal with assistance from FINNIDA, the Asian Development Bank and many other donor agencies. Copies may be obtained from Rabi Bista, MPFD Project, Ministry of Forests and Soil Conservation, Kathmandu, Nepal. The general outline may be gathered from the selected details.

The area of forested land is 5.5Mha, 37% of the land surface. Of this, 15% is dense forest with 70% crown cover and 1% is of young pole sized trees. The loss of forest since 1964 (to 1988) is 570,000ha during which time the government has planted 47,300ha of plantation and community planting as accounted for a further 21,900ha. The percentage of broadleaved forest is 59%, of conifer 17% with the balance being mixed.

The forests provide 15% of the Gross Domestic Product. Fodder from forest land provides over 40% of the nutrition for livestock and in conjunction with shrubland, the forest fuelwood provides 75% of the Country's energy. The collection of fuelwood and fodder and other forest occupations employ 1.33M people. Forest management needs to take account of the sustained supply of potable water and water for irrigation and as a source of energy. The National Parks and wildlife resources play a significant role in the welfare of the tourist industry.

The Master Plan assesses that a further 0.5Mha would be lost if current forest clearing trends continue up to 2012. Fuelwood is already in deficit by 2.1MT and by 2000 would be 3.2MT. New planting of 0.4Mha would curtail this deficiency to the current 2.1MT.

The current timber deficit is 0.25Mm³ and would be 1.1Mm³ by 2000 and would be far worse by 2010 unless the existing forest is managed soundly and new plantations have come into production. The area required to keep the deficit down to 1.1Mm³ by 2010 would be 0.4Mha.

The long term objectives of the Plan are to provide the public with fuelwood, the stock with fodder, to provide timber, to protect the land and water resources, to conserve the ecosystem and genetic resource and to contribute to the local and national economy. In the medium term, rural development will be encouraged which acknowledges the need to improve the legal framework to foster tree planting and conservation.

The projects which have been identified have been listed under the following headings:- Community and Private Forestry, National and leasehold forestry, Medicinal and aromatic plant propagation and utilization, forest based development, soil conservation and watershed management, conservation of ecosystems and genetic resources, development of forest resources information systems and management planning, forest research and extension, human resource development, monitoring and evaluation, institutional reform and policy and legal reform.

The outlay on this Plan will be $1.5 billion over 25 years with the government finding 40%. The results would be an increase in fuelwood from the 7.3MT of '85-'86 to 10.4MT in 2000-01 and 15MT in 2010-11. Fodder would increase from 14.6MT in '85-'86 to 18.24MT in 2000-01 and 24.3MT in 2010-11. Over the same period, timber would
increase from 0.88Mm$^3$ to 1.58Mm$^3$ and then 3.28Mm$^3$. New employment by 2010 would represent 2.2M man years of full time jobs. Implementation of the Master Plan would show an economic internal rate of return of 35.5%.

UGANDA

The Uganda Forestry Association was formed on December 9th 1986. It is a non-government, non profit making, voluntary organisation which is open to all those who are prepared to take positive steps to save what remains of Uganda’s natural forest and to foster public appreciation of the benefits the existing woodland offers. The 1987 UNEP satellite pictures of the country indicate that the forest cover is now 677,533 ha compared with the 1,693,833 ha of 1964. Even the remaining woodland has lost much of the more valuable trees through the action of pit-sawyers. The FAO and World Bank figures suggest that the country’s timber and wood fuel requirements are already 20% over the sustainable figure and that at these rates all of the woodland would be lost by 2000. The Association is setting out to demonstrate to the public the adverse effects upon climate, the environment and natural resources which would follow from the loss of the forests. A key role is foreseen for the establishment and caring of village wood-lots. The public relations operation will involve the preparation, demonstration and presentation of the appropriate message to all sections of the community, including the use of posters and booklets in the main languages.

The officers of their Executive Committee are all foresters, the Chairman Dr. J. R. W. Aluma, Secretary, S. W. Gomya-Ssembajjwe and Assistant Editor at the Forestry Department at Makerere University, PO Box 7062, Kampala, the Vice-Chairman and the Treasurer are from the Forest Department at Entebbe, PO Box 31 and the Chief Editor and the Assistant General Secretary are from the Forest Research Centre at Nakawa, PO Box 1752, Kampala. Local subscriptions will enable members to be circulated with the notices of meetings, but international funds of $50,000 are being solicited for the major nursery and extension programmes.
PERFORMANCE OF HIBISCUS ELATUS IN PUERTO RICO

By J. K. FRANCIS* and P. L. WEAVER*

SUMMARY

Hibiscus elatus in Puerto Rico was surveyed on 34 plantation plots ranging in age from 6.5 to 27 years and, in species adaptability trials, on 97 plots ranging in age from 0.9 to 7.0 years. Three life zones and two soil orders were represented. The standing volumes for the sample plots ranged from 97 to 979 m³/ha, yielding growth rates of 4.5 to 36.0 m³/ha yr. Mean annual diameter increment ranged from 0.64 to 2.52 cm yr and mean annual height increment from 0.5 to 2.6 m yr. Defects such as large epicormic branches and sweep were common but varied among plots. Crown-to-bole ratios averaged 20.3 for 80 sampled trees. The mean specific gravity for Hibiscus on five different sites was 0.50 g/cm³ and ranged from 0.40 to 0.53. The performance of Hibiscus was compared with sites elsewhere in the Caribbean Basin and in Hawaii.

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Introduction

_Hibiscus elatus_ Sw. (blue mahoe, mahoe, emajagua, Cuban bast), an evergreen tree, commonly reaches 25 m in height and 40 cm at diameter breast height (d.b.h.). However, on favourable sites it may attain diameters approaching 1 m (Longwood 1962) and heights approaching 35 m. Native to Cuba (Adams 1971) and Jamaica (Little _et al._ 1974), it is widely planted on both islands and has naturalized in southern Florida, Mexico, Peru, Brazil, and throughout the West Indies (Chudnoff 1984).

Mahoe is a high grade furniture wood prized for its steel gray heartwood, which is richly variegated with shades of purple, metallic blue, and olive green (Record and Mell 1924; Swabey 1941, 1945; Record and Hess 1943; Longwood 1962; Chudnoff 1984). The timber is also suitable for turnery, flooring, framing, building construction, boat building, agricultural implements, and railway sleepers (Natural History Society of Jamaica 1946; Longwood 1962; Little _et al._ 1974). In the past, the inner bark was used for making rope and cord that were very durable in salt and brackish water (Longwood 1962).

Mahoe was first introduced to Puerto Rico in the mid-1940's (Tropical Forest Experiment Station 1952) and was subsequently tested in species adaptability trials. Despite its wide use in the Caribbean, relatively little information could be found on its performance. The purpose of this paper is to summarize the Puerto Rican experience with mahoe.

Methods

All sampled plantations and species adaptability trials were established between 1960 and 1980. Trees planted before then could not be relocated.

Three life zones (sensu Holdridge 1967) and two soil orders were represented in the plantation plots and species adaptability trials (Fig. 1; Table 1). Annual rainfall ranged

![Figure 1](image-url)
from 1500 mm in the subtropical moist forest at Cambalache to 3000 mm in the arboretum and Sabana areas of the Luquillo Mountains (Calvesbert 1970).

Table 1
Environmental characteristics of **Hibiscus elatus** (mahoe) plantations in Puerto Rico.

<table>
<thead>
<tr>
<th>Location</th>
<th>No. plots</th>
<th>pH range</th>
<th>Soil information¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luquillo</td>
<td>9</td>
<td>4.3-6.0</td>
<td>Tropohumult; clay (5), silt loam (2), clay loam (1), sandy clay loam (1).</td>
</tr>
<tr>
<td>Cambalache</td>
<td>5</td>
<td>5.0-5.8</td>
<td>Tropudalf; clay (5).</td>
</tr>
<tr>
<td>Carite</td>
<td>6</td>
<td>4.6-5.0</td>
<td>Tropohumult; clay (2), loam (2), silty clay loam (2).</td>
</tr>
<tr>
<td>Guajataca</td>
<td>4</td>
<td>6.5-7.6</td>
<td>Tropudalf; silt loam (4).</td>
</tr>
<tr>
<td>Río Abajo</td>
<td>6</td>
<td>4.8-7.3</td>
<td>Tropudalf; sandy loam (3), silt loam (1), clay loam (1), clay (1).</td>
</tr>
<tr>
<td>Toro Negro</td>
<td>4</td>
<td>5.0-5.1</td>
<td>Tropohumult; loam (2), sandy loam (2).</td>
</tr>
</tbody>
</table>

¹ Number of plots in parentheses.

Thirty-four mahoe plantations, ranging in age from 6.5 to 27 years, were sampled in early 1987 on plots having a 10 m radius. All sample plots were well-stocked and, except for the arboretum plot, were surrounded by additional mahoe to provide comparable information by site. The arboretum plot, small with a significant edge effect, was eliminated from calculations of basal area and volume. In addition, height growth was summarized for mahoe from 97 plots ranging in age from 0.9 to 7.0 years in species adaptability trials. The trials included mahoe interspersed with other tree species in 3 x 3 m spacings. The effects of competition on mahoe in these plots was assumed to be minimal because mahoe grows rapidly and tolerates spacings as dense as 1.8 x 1.8 m at an early age.

On all plots, the b h of trees ≥5 cm was measured to the nearest 0.1 cm with a diameter tape. Total heights were measured to the nearest 0.5 m with a relascope. Multiple stems were tallied separately if bifurcation occurred below b h.

The relationship (0.5 x basal area x height) was used to determine stem volumes (Newbound 1967). Four measurements of crown radius were made on cardinal directions, summed, and divided by two to derive a mean crown diameter; this was divided by d b h to derive the crown-to-bole (CD/BD) ratios. Increment cores 1 cm in diameter, extending from the cambium to the centre of the tree, were taken at b h. Green volumes were determined by immersion. Specific gravities (ovendry weight of the core divided by the green volume) for sample trees on each of the plots were then determined.

Clear bole length was determined on dominant trees. Tree defects were noted for all stems, and the presence or absence of reproduction was observed in each stand. Mahoe
Table 2
Estimates of number of stems and basal area for *Hibiscus elatus* (mahoe) plantations in Puerto Rico.

<table>
<thead>
<tr>
<th>Forest</th>
<th>Age (yr)</th>
<th>Stems/ha</th>
<th>Basal area (m²/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>Mahoe</td>
</tr>
<tr>
<td>Luquillo Caracoles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>25</td>
<td>1167</td>
<td>833</td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td>1033</td>
<td>967</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>1000</td>
<td>867</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>1133</td>
<td>567</td>
</tr>
<tr>
<td>Sabana</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1</td>
<td>26</td>
<td>1033</td>
<td>900</td>
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<tr>
<td>2</td>
<td>26</td>
<td>1000</td>
<td>667</td>
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<td>900</td>
<td>833</td>
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<tr>
<td>4</td>
<td>26</td>
<td>1200</td>
<td>1167</td>
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<tr>
<td>Cambalache</td>
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<td></td>
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</tr>
<tr>
<td>1</td>
<td>6.5</td>
<td>1967</td>
<td>1967</td>
</tr>
<tr>
<td>2</td>
<td>6.5</td>
<td>1867</td>
<td>1867</td>
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<tr>
<td>3</td>
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<td>3</td>
<td>16</td>
<td>967</td>
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<tr>
<td>6</td>
<td>19</td>
<td>2067</td>
<td>1567</td>
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<tr>
<td>Guajataca</td>
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<td>1</td>
<td>17</td>
<td>1467</td>
<td>1467</td>
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<tr>
<td>2</td>
<td>17</td>
<td>1733</td>
<td>1600</td>
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<tr>
<td>3</td>
<td>24</td>
<td>867</td>
<td>867</td>
</tr>
<tr>
<td>4</td>
<td>8.5</td>
<td>300</td>
<td>300</td>
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<tr>
<td>Río Abajo</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>2167</td>
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<td>20</td>
<td>1167</td>
<td>667</td>
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<tr>
<td>6</td>
<td>20</td>
<td>2100</td>
<td>1500</td>
</tr>
<tr>
<td>Toro Negro</td>
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</tr>
<tr>
<td>1</td>
<td>21</td>
<td>967</td>
<td>867</td>
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<tr>
<td>4</td>
<td>6.5</td>
<td>1567</td>
<td>1200</td>
</tr>
</tbody>
</table>
seed capsules were collected and dried in a solar drier until they opened. The seeds were removed, weighed, and refrigerated in sealed plastic bottles for a month, after which they were sown in moist sand and on the surface of moist peat.

Finally, at each plot centre, a soil sample was extracted with a soil auger to a depth of 30 cm. The hydrometer method was used to determine soil texture (Wilde and Voigt 1959), and pH was measured with a glass electrode.

Results

Soils on the plots were derived from igneous rocks and limestone and are comprised of a variety of soil textures, with pH values of 4.3 to 7.6 (Table 1). Soil drainage classes (Soil Survey Staff 1951) range from poorly drained to well drained.

The edge of the one Cambalache plot was excessively drained, and trees were much shorter than on deeper and more level soils. Two Luquillo plots, having wet, poorly drained soils, showed possible signs of stress in pale coloured foliage and abbreviated crowns in overstory trees.

Stand characteristics — The 34 plantation plots were of two age groups: between 6.5 and 8.5 years old and between 16 and 27 years old (Table 2). The total number of stems for all plots ranged from 300 to 2167/ha, with all but three plots containing >800 stems/ha. For plantings between 16 and 27 years old, basal areas for all stems ranged from 20 to 77 m$^2$/ha.

Growth — For plantings between 6.5 and 8.5 years old, volumes ranged from 90 to 154 m$^3$/ha, with mean annual volume increments (mai) between 14.4 and 23.7 m$^3$/ha.yr (Fig. 2). For plantings between 16 and 27 years old, volumes of mahoe alone ranged from 97 to 979 m$^3$/ha and mai from 4.5 to 36.0 m$^3$/ha.yr.

Mean diameters and heights of mahoe are presented in Table 3. These data

![Figure 2. Volume growth of *Hibiscus elatus* in several plantations in Puerto Rico.](image-url)
Table 3
Estimates of diameter and height for *Hibiscus elatus* (mahoe) plantations in Puerto Rico.

<table>
<thead>
<tr>
<th>Forest Site</th>
<th>Age (yr)</th>
<th>D.B.H. (cm)</th>
<th>Height (m)</th>
<th>D.B.H. (cm)</th>
<th>Height (m)</th>
<th>Clear bole (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Luquillo</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caracoles</td>
<td>1</td>
<td>25</td>
<td>17.3 ± 1.82</td>
<td>13.4 ± 0.41</td>
<td>22.5</td>
<td>14.3</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>25</td>
<td>17.8 ± 1.25</td>
<td>13.4 ± 0.38</td>
<td>22.6</td>
<td>14.7</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>25</td>
<td>17.9 ± 2.38</td>
<td>13.8 ± 0.84</td>
<td>28.2</td>
<td>16.5</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>25</td>
<td>16.9 ± 5.25</td>
<td>14.9 ± 2.10</td>
<td>50.7</td>
<td>21.0</td>
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<td><strong>Sabana</strong></td>
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</tr>
<tr>
<td></td>
<td>1</td>
<td>26</td>
<td>19.7 ± 2.11</td>
<td>17.9 ± 1.21</td>
<td>28.9</td>
<td>24.2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>26</td>
<td>18.1 ± 2.86</td>
<td>16.2 ± 1.42</td>
<td>32.2</td>
<td>23.0</td>
</tr>
<tr>
<td></td>
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correspond to mean annual diameter increments (madi) of 1.52 to 2.52 cm/yr for plots 6.5 to 8.5 years old, 0.64 to 1.23 cm/yr for plots 16 to 21 years old, and 0.68 to 1.68 cm/yr for plots 24 to 27 years old. Mean annual height increments (mahi) ranged from 1.8 to 2.6 m/yr for the younger plots, 0.7 to 1.3 m/yr for plots 16 to 21 years old, and 0.5 to 1.0 m/yr for the oldest plots. The best growth was attained for the 8.5-year-old plot that had been thinned at Guajataca. It was situated on colluvial soils between limestone hills.

The analysis of height growth, using all plantation data and information from the adaptability trials, yielded the relationship

\[ H = -0.41X^{1.5} + 3.06X - 2.04 \quad (r^2 = 0.90, \text{Sy.x} = 2.52), \]

where \( H \) equals height and \( X = \text{age} \) for both species trial and plantation data combined (Fig. 3). Considerable variation in height is evident at any given age.

**Other factors** — Epicormic branching was a common defect that occurred on 62 percent of the plots, with a frequency of 1 to 88 percent of the trees sampled. Other form defects, mainly sweep, existed in all but one plot, with 6 to 79 percent of the trees sampled per plot being affected. Epicormic branching was more prevalent in humid than dry areas, whereas the incidence of sweep was apparently not related to site. Butt scars were rare and could be traced to fire or mechanical damage.

The mean CD/BD ratio for 80 sampled trees across all sites was 20.3 ± 0.7 (geometric mean CD/BD = 21.1 ± 0.7). The mean site values for specific gravity (in g/cm³ with number of samples in parentheses) were: Luquillo, 0.53 ± 0.02 (10); Carite, 0.53 ± 0.03 (6); Guajataca, 0.48 ± 0.02 (4); Rio Abajo, 0.48 ± 0.02 (6); and Toro Negro, 0.40 ± 0.02 (4). The mean specific gravity for all 30 samples of mahoe, regardless of site, was 0.50 ± 0.01 g/cm³. Although the range of values is considerable, a standard one-way ANOVA did not detect significant differences amongst them.
Germination testing of mahoe seeds yielded 6-percent success after 2 weeks on moist sand and zero-percent success on peat moss. Between 2 and 4 months, an additional 14 percent germinated on moist sand. Seed weight was 2.1 g per 100 seeds, or 47,600 seeds/kg.

Flowering and seed production occurred at all sites. Seedlings and saplings were absent from plots ≤6.5 years old and present on all plots ≥16 years old, with the exception of one well-drained plot at Cambalache and half the plots at Carite. A few of the trees from the 6.5-year-old stands had flowers at the time of sampling.

Discussion

Environmental information — Mahoe is adapted to a wide range of sites in Puerto Rico (Fig. 1; Table 1) and earlier was recommended for planting on 60,000 ha of sandy, well-drained granitic uplands, with rainfall between 1650 and 2500 mm/yr (Geary and Briscoe 1972). In areas receiving ≥1500 mm/yr of rainfall, most sites seem acceptable, except edaphically droughty (e.g., shallow soils over bedrock), very poorly drained soils and severely eroded or nutrient-depleted sites. This wide range of adaptability is congruent with mahoe’s distribution in its native habitat. In Jamaica, it exists on moist limestone soils at 150 m and on shales and residual volcanic soils to over 1200 m (Swabey 1940; Storer 1958). Normally, rainfall is between 1800 and 3800 mm/yr, but on alluvial plains mahoe survives with 1000 mm/yr or less. In Cuba, the occurrence of mahoe is reported from a wide range of sites (Smith 1954), including dry areas where it is a smaller tree. There is some confusion regarding the classification of mahoe in Cuba, however, because it is frequently referenced as Hibiscus sp., a designation that does not distinguish it from closely related H. tiliaceus. The latter species occurs at lower elevations, in particular along the coast (Little and Wadsworth 1964).

Growth — Considerable variation in the growth of mahoe is apparent, but the lack of periodic measurements of the plantations made detailed growth analyses impossible. The measurements examined herein (diameter, height, basal area, and volume) are satisfactory for the sites sampled in Puerto Rico. In a study of 31 introduced species in Puerto Rico’s granitic uplands, mahoe had 72 percent of the survival and 99 percent of the height growth of Honduras pine, the standard used for comparisons among the species (Geary and Briscoe 1972). Success with mahoe in Puerto Rico has resulted in its being planted on 22 ha between limestone hills of the Rio Abajo Forest where current sawtimber volume averages 128 m³/ha (Cabarle 1985).

Comparative growth information for mahoe is available from other sources (Table 4). In Caribbean locations, where it is a favoured plantation species, madi varied between 0.9 and 3 cm/yr and mahi between 0.9 and 2.1 m/yr for ages 7 to 19 years (unpublished data). In Hawaii, the early results of species adaptability trials showed good survival on six sites, but height growth was slower than in Puerto Rico (Whitesell and Walters 1976). Mahoe was judged as promising on five of seven sites where it was tested.

Other factors — The practices used in this study for seed collection and drying were similar to those reported for Jamaica (Swabey 1940). There, mahoe seeds ripen in March and April when the capsules are picked and laid in the sun to dry. Seed weight in Jamaica was slightly less, averaging 1.8 to 1.9 g/100 seeds. Our low germination, and its occurrence in two distinct periods after sowing, reflects a problem with the propagation of mahoe. In Jamaica, germination was comparatively high, averaging 80 percent after seed collection, remaining good for 4 months, and then declining after 6 months (Swabey 1940). In contrast, seed dormancy in Cuba was reported to be one of the principal problems affecting the propagation of mahoe (Lopez Almirall 1981). Seeds were often
Comparative data for *Hibiscus elatus* from previously published sources.

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¹ Whitesell and Walters 1976. Five replicated blocks with 10 or more randomized row plots, with each plot containing 6 trees from seed lot for a total of 30 seedlings tested.

² Wadsworth 1960.

³ Swabey 1940.

⁴ Tropical Forest Experiment Station 1952.

⁵ Weaver and Lugo 1981.

dormant at the time of dissemination, a phenomenon that apparently varied according to environmental conditions.

In Jamaica, mahoe seedlings are transplanted after 1 year, when they range in height from 45 to 60 cm (Swabey 1940). Rapid growth generally commences about 6 months after outplanting. In Cuba, the growth of seedlings has been enhanced by fertilization with N and P (Hernandez and Alonso 1985). Optimum spacing is probably 3 x 3 m. Management should involve thinning within the first 10 years for posts, poles, or small pulpwood.

Epicormic branching was previously reported for Jamaica, even with plantings as dense as 1.8 x 1.8 m (Swabey 1940). Wider spacing and pruning are suggested as means to overcome this problem if the expense can be justified. Otherwise, the tall, straight, multiple stems developing from epicormic branches on the lower bole are useful as posts, poles, and pulpwood. Although epicormic sprouting is more common in wet areas, the problem is neither consistent enough nor well enough understood to be avoided in site selection. Apparently, the habit is heritable, so genetic selection may offer a solution.

Mahoe is relatively free of plant pests and diseases, with only occasional reports of damage. In Jamaica, leaf spots caused by *Septoria* sp. and *Pestalstia heterocornis* Guba were observed (Leather 1967), and unconfirmed reports of heartrot in thinned mahoe stands were mentioned (Pawsey 1970). In Puerto Rico, a dieback characterized by crown
branching, leaf wilt, and blackening of the trunk was observed in the earliest plantations (Tropical Forest Experiment Station 1952). The causal agent was unknown, and further damage has not been reported. When used in construction, mahoe is highly resistant to attack by decay fungi (Chudnoff 1984). No data could be found on its resistance to termite attack. However, closely related H. tiliaceus was ranked as susceptible to attack by the dry-wood termite Cryptotermes brevis Walker (Wolcott 1957).

In addition to its value as a timber species, mahoe has been used for windbreaks in Cuba, despite its tendency to lose leaves during dry spells (Gindel 1972). The earliest descriptions of mahoe indicate that it is intolerant of exposed conditions and that it is susceptible to wind damage (Swabey 1940). More recent observations confirm this. In the Puerto Rican hurricane of 1956 (Wadsworth and Englerth 1959) and the Jamaican hurricane of 1980 (Thompson 1983), mahoe was found to be windfirm but susceptible to limb breakage.

The local variation in specific gravity noted for mahoe in Puerto Rico was observed earlier in Jamaica. In limestone forests, where the wood was reputed to be denser and stronger, it had a specific gravity of 0.49 g/cm$^3$; in the Blue Mountains, it was 0.36 g/cm$^3$ (Lamb, Briscoe and Englerth 1960). Other observations of specific gravity include a value of 0.62 g/cm$^3$ (Chudnoff 1984) and a green weight of 0.74 g/cm$^3$ (Swabey 1941). Apparently, specific gravity is partially dependent on site, being slightly denser in drier areas where trees are slower growing.

Reproduction begins at a relatively young age in mahoe and even occurs in the shade under closed stands. Drought is a limiting factor on well-drained sites where rainfall is $\leq 1500$ mm/yr. However, the production of only an occasional seedling in Carite, which has no apparent climatic or edaphic limitations, cannot be explained.

In summary, mahoe is a high value, fast-growing timber species that adapts to a wide range of sites. Local knowledge of mahoe's utility has led to its being planted in many Caribbean countries.

Acknowledgments
The authors are indebted to William E. Balmer, Consultant Forester, Chamblee, GA, for helpful comments.

REFERENCES


CULTIVATION OF MULTIPURPOSE TREES
IN RAIN WATER HARVESTING SYSTEMS IN THE
ARID ZONE OF ISRAEL

By Y. ZOHAR1, J. A. ARONSON2 and H. LOVENSTEIN3

SUMMARY
A long-term project was initiated to select appropriate species, develop management
practices and evaluate the overall potential for producing fuelwood and
multipurpose trees in agroforestry systems using rainfall harvesting techniques in an
arid region. This paper presents data on the fresh and oven-dried above-ground
biomass yields, energy production, as well as fodder features of Eucalyptus
occidentalis and Acacia salicina grown in 2 or 4-year rotation cycles without
supplementary irrigation. The study was conducted at the Wadi Mashash experiment
farm of the Desert Run-off Farms Unit in an area receiving only 115 mm mean
annual precipitation.

The mean annual fresh biomass per tree for the first two rotations of 2 years was 30
kg for E. occidentalis and 25 kg for A. salicina. For the 4-year rotation there was
almost 60 kg tree\(^{-1}\) for E. occidentalis and 30 kg tree\(^{-1}\) for A. salicina. The
data presented in this paper highlight the significant potential for developing
sustained productive fuelwood plantations, or alternatively integrated agroforestry
plantations, in arid and semiarid regions relying entirely on run-off water.

Key words: rainfall-harvesting; fuelwood plantations; agroforestry; Eucalyptus
occidentalis; Acacia salicina; arid and semiarid regions.

RÉSUMÉ
Un projet à long terme fut inauguré pour choisir des essences appropriées,
développer des techniques d’aménagement et évaluer les possibilités d’ensemble
pour la production de bois de chauffage et des arbres à usages multiples dans des
systèmes agroforestiers en utilisant des techniques de récolte des précipitations dans
une région aride. Cet article présente des données sur les rendements de biomasse
aérienne verte et anhydre, la production d’énergie, bien que les caractéristiques
fourragères d’Eucalyptus occidentalis et Acacia salicina cultivés en des rotations de 2
ou 4 ans sans irrigation d’appoint. L’étude fut réalisée à la ferme de recherche Wadi
Mashash de l’Unité des Fermes Désertiques d’Écoulement dans une région qui ne
reçoit que 115 mm de précipitations moyennes annuelles.

La biomasse verte moyenne annuelle par arbre pour les deux premières rotations
de 2 ans furent 30 kg pour E. occidentalis et 25 kg pour A. salicina. Pour la rotation de

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Gurion University of the Negev, Beer Sheva 84110, Israel.
3 Desert Runoff Farms Unit, Blaustein Institute of Desert Research, Ben-Gurion University of
the Negev, Sde Boqer 84993, Israel.

Contribution from the Agricultural Research Organization, Bet Dagan, Israel. No. 2403–E 1988
series.
4 ans il y eut presque 60 kg par arbre et par an pour *E. occidentalis* et 30 kg par arbre et par an pour *A. salicina*. Les données présentées dans cet article soulignent les possibilités considérables pour le développement de plantations de bois de chauffage à production soutenue ou bien des plantations agroforestières intégrées dans des régions arides ou semi-arides dépendant complètement de l’écoulement.

**RESUMEN**

Se inició un proyecto a largo plazo para seleccionar especies apropiadas, desarrollar prácticas de manejo y evaluar el potencial general para producción de lena y árboles de uso múltiple en sistemas agroforestales, utilizando técnicas de captación de lluvia en regiones áridas. Este artículo presenta datos sobre la producción de biomasa verde y seca al horno, producción de energía, así como propiedades forrajeras de *Eucalyptus occidentalis* y *Acacia salicina*, cultivadas en rotaciones de dos o cuatro años sin irrigación. El estudio se llevó a cabo en la finca experimental Wadi Mashash de la Unidad de Fincas de Desierto de Escorrentía, en un área que recibe apenas 115 mm anuales de precipitación.

El promedio anual de biomasa verde por árbol para las primeras dos rotaciones de dos años fue 30 k para *E. occidentalis* y 25k para *A. salicina*. Para la rotación de cuatro años esta producción fue 60 k·año⁻¹ para *E. occidentalis* y 30 k·año⁻¹ para *A. salicina*. Los datos que se presentan en este documento resaltan el significado potencial de las plantaciones de lena productivas y sostenidas, o alternativamente, plantaciones agroforestales integradas, en regiones áridas y semiáridas que dependen por completo del agua de escorrentía.

**Introduction**

One of the most pressing needs in the arid and semiarid regions of many developing countries is an adequate, renewable supply of firewood for local village use and of charcoal for urban use (Eckholm, 1975; Sirin and Mitchell, 1985; U.N., 1977). By the year 2000, as many as 2.4 to 3 billion people in the Third World may be affected by an acute shortage of fuelwood (Agric. Univ. Wageningen, 1983; Sirin and Mitchell, 1985) and of these a large percentage will be living in arid and semiarid regions of the subtropical latitudes. Still, very little useful information is available on fuelwood crop planting in hot desert areas. Even where tree plantings have been undertaken in such areas, very little or no attention has been devoted to the development of appropriate, sustainable management systems to achieve the highest biomass yields per unit area, time and water at minimum cost and with minimum effort.

Over the past 10 years Israeli investigators have accumulated considerable experience in selecting useful trees and shrubs for planting in arid and semiarid regions (Aronson, Birnbaum and Forti, 1984; Weinstein, 1985; Zohar, 1974a; b; Zohar and Karschon, 1984; Zohar and Moreshet, 1987). At the same time, expertise has been developed in the management of rainfall-harvesting systems for the production of food, fodder and industrial crops (Evenari, Shanan and Tadmor, 1975, 1981). Rainfall harvesting basins have also been extensively used to provide recreational ‘oases’ in desert areas without the need for supplementary irrigation (Karschon and Kaplan, 1981).

The primary objective of the research presented here was to test the feasibility of raising fast-growing multipurpose tree species in rainfall-harvesting basins in a typical desert region.
Site Description

The Wadi Mashash farm of the Desert Run-off Farms Unit affiliated with the Jacob Blaustein Institute for Desert Research is a 15-year-old facility on 600 hectares of gently undulating land, established to study the commercial feasibility of growing various crops in arid regions by rainwater-harvesting (Evenari et al. 1981). The site is at 31° 08'N, 34° 53'E, 400 m above sea level, and 65 km from the Mediterranean Sea (Fig. 1).

Based on rainfall data collected at the farm since 1973, the mean annual precipitation is 115.2 mm. However, rainfall here, as throughout the Negev, is characteristically localized and unpredictable. This becomes clear when it is observed that the range of annual rainfall during the 14 years of meteorological observations was from 55.0 to 180.5 mm. Thus the amount of mean annual precipitation is of only limited significance, and must be interpreted carefully. It is, however, important to note that average annual evaporation at the site varies between 2500 and 3500 mm, as measured by a Class A pan. The mean minimum temperature for the coldest month is 1.1°C, and the mean maximum temperature for the hottest month is 41.6°C. The relative humidity for January and July averages 55.1% and 40.4%, while the daily evapotranspiration for these 2 months averages 3.0 mm and 10.3 mm, respectively (Wadi Mashash Farm meteorological data, 1987).

Materials and Methods

In the winter of 1982/83, three water-catchment basins (called ‘limans’ in Israel, from the Greek word *limna* — pond) of 0.35 ha each were constructed with a Caterpillar 950 tractor. Eight days after the first rain-induced flood of that year (Jan. 23–25, 1983), seedlings of *Eucalyptus occidentalis* and *Acacia salicina* were planted at a spacing of 5 x 5 m. Each species was planted in three randomized block replicates of 12 trees per liman. The seedlings used were of average quality, from the standard nursery of the J.N.F. forest service.

The monthly rainfall distribution (mm) and data on significant floods (m³·ha⁻¹) in the experimental limans from the date of planting until the end of the rotations are shown in Figures 2 and 3.

After 2, 3, 4 years *E. occidentalis* and *A. salicina* were harvested. Since January had been found to be the best month for tree felling under the conditions in the Negev
The trees were cut at a uniform height of 20 cm above ground level, and the following measurements were carried out:

a. Diameter (cm) at 1.3 m for *E. occidentalis* (D B H) and at 0.3 m for *A. salicina* (below the first main branching).
b. Height (m). Diameter and height for *E. occidentalis* were related to the largest trunk per tree.
c. Fresh weights (kg) of the total above-ground biomass.
d. Separate determination of the oven-dry weight of wood, bark, branches and leaves (kg).
e. Separate determination of the gross calorific value for each component (KJ.g⁻¹), with an oxygen bomb calorimeter.
f. Fodder quality was determined as the rate of digestibility (Tilley and Terry) and protein level of the leaves (Kjeldahl).

**Results**

The data on tree size, total fresh and oven-dried biomass of *E. occidentalis* and *A. salicina* at different cutting rotations are given in Table 1. The increase in the total biomass per year was related to the length of the cutting rotation. The second rotation of 2 years exhibited a significantly higher biomass relative to the first rotation.
## Table 1

Average Tree size, Fresh and Oven-dried Biomass of *Eucalyptus occidentalis* and *Acacia salicina* according to cutting rotation\(^z\). (Percent of tree components is based on oven-dried biomass)

<table>
<thead>
<tr>
<th>Cutting rotation (yrs)</th>
<th>Diameter(^y) (cm)</th>
<th>Height(^y) (m)</th>
<th>Total fresh biomass (kg)</th>
<th>Total oven-dried biomass (kg)</th>
<th>Percent of total wood</th>
<th>bark</th>
<th>branches(^x)</th>
<th>leaves</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2)</td>
<td>7.4 ± 2.0</td>
<td>4.6 ± 0.3</td>
<td>39.7 ± 11.3</td>
<td>21.1 ± 6.0</td>
<td>29.4</td>
<td>8.1</td>
<td>17.5</td>
<td>45.0</td>
</tr>
<tr>
<td>3</td>
<td>9.0 ± 1.1</td>
<td>5.8 ± 0.7</td>
<td>87.6 ± 20.5</td>
<td>46.8 ± 10.2</td>
<td>40.8</td>
<td>7.9</td>
<td>14.4</td>
<td>36.9</td>
</tr>
<tr>
<td>4</td>
<td>12.8 ± 1.0</td>
<td>7.0 ± 0.4</td>
<td>230.2 ± 8.3</td>
<td>119.2 ± 3.5</td>
<td>39.8</td>
<td>8.7</td>
<td>13.9</td>
<td>37.6</td>
</tr>
<tr>
<td>2(^w)</td>
<td>5.0 ± 0.2</td>
<td>4.7 ± 0.7</td>
<td>80.7 ± 9.4</td>
<td>40.7 ± 5.2</td>
<td>31.7</td>
<td>8.6</td>
<td>17.7</td>
<td>42.0</td>
</tr>
<tr>
<td>(2)</td>
<td>7.4 ± 0.8</td>
<td>2.6 ± 1.1</td>
<td>24.4 ± 6.1</td>
<td>13.8 ± 3.1</td>
<td>15.3</td>
<td>5.0</td>
<td>29.0</td>
<td>50.7</td>
</tr>
<tr>
<td>3</td>
<td>10.8 ± 1.1</td>
<td>3.0 ± 0.3</td>
<td>56.9 ± 10.8</td>
<td>27.2 ± 5.2</td>
<td>26.1</td>
<td>6.3</td>
<td>27.9</td>
<td>39.7</td>
</tr>
<tr>
<td>4</td>
<td>17.4 ± 2.0</td>
<td>4.6 ± 0.5</td>
<td>128.0 ± 21.2</td>
<td>59.6 ± 12.6</td>
<td>33.2</td>
<td>9.6</td>
<td>14.0</td>
<td>38.2</td>
</tr>
<tr>
<td>2(^w)</td>
<td>6.0 ± 0.7</td>
<td>3.3 ± 0.3</td>
<td>77.7 ± 21.2</td>
<td>34.4 ± 9.6</td>
<td>24.4</td>
<td>7.0</td>
<td>24.1</td>
<td>44.5</td>
</tr>
</tbody>
</table>

\(^z\) Each measurement is the average (± S.D.) of 12 trees in three blocks.

\(^y\) Diameter (d.b.h.) height of *E. occidentalis* is related to the largest trunk per tree. The diameter for *A. salicina* was taken at 30 cm (under the first main branching).

\(^x\) Branches > 1 cm in diameter.

\(^w\) Second cutting rotation.
Table 2
The energy production (MJ. tree\(^{-1}\)) of different tree components of \textit{Eucalyptus occidentalis} and \textit{Acacia salicina} according to cutting rotation.

<table>
<thead>
<tr>
<th>Cutting rotation (yrs)</th>
<th>Wood</th>
<th>Bark</th>
<th>Branches</th>
<th>Leaves</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>\textit{E. occidentalis}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>113.6</td>
<td>32.0</td>
<td>68.6</td>
<td>201.6</td>
<td>415.8</td>
</tr>
<tr>
<td>3</td>
<td>349.9</td>
<td>69.7</td>
<td>126.1</td>
<td>365.0</td>
<td>910.7</td>
</tr>
<tr>
<td>4</td>
<td>868.4</td>
<td>195.9</td>
<td>307.9</td>
<td>950.7</td>
<td>2322.9</td>
</tr>
<tr>
<td>2(^z)</td>
<td>236.3</td>
<td>65.9</td>
<td>133.6</td>
<td>362.9</td>
<td>798.7</td>
</tr>
<tr>
<td>\textit{A. salicina}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>38.4</td>
<td>12.7</td>
<td>72.7</td>
<td>120.2</td>
<td>244.0</td>
</tr>
<tr>
<td>3</td>
<td>129.8</td>
<td>30.9</td>
<td>138.1</td>
<td>185.4</td>
<td>484.2</td>
</tr>
<tr>
<td>4</td>
<td>361.9</td>
<td>103.7</td>
<td>205.3</td>
<td>391.5</td>
<td>1062.4</td>
</tr>
<tr>
<td>2(^z)</td>
<td>153.6</td>
<td>43.7</td>
<td>150.8</td>
<td>262.7</td>
<td>610.8</td>
</tr>
</tbody>
</table>

\(^z\) Second cutting rotation

The ratio of the leaf biomass to the woody components was highest in the 2-year rotation. Figure 4 presents the gross calorific values of these species. The values of the leaves of \textit{E. occidentalis} are higher relative to the woody components, whereas for \textit{A. salicina} the woody components had higher values.

Table 2 is based on data from Table 1 and Figure 4. The data indicate that for both species, in the 2-year rotation, 48\%-49\% of the total energy production was concentrated in the leaves, which added mainly to a higher leaf percentage, rather than to changes in energy content. This ratio decreased with age.

The total energy production in the first rotations was 70\% higher for \textit{E. occidentalis} than for \textit{A. salicina} in the 2-year rotation, up to 120\% higher in the 4-year rotation, and reduced by up to 30\% during the second rotation of 2-years (Table 2).

The digestibility (%), the protein content (%) and protein level kg.tree\(^{-1}\) of \textit{E. occidentalis} and \textit{A. salicina} in the 2 and 4-year rotation are given in Figure 5. The protein percentage of \textit{A. salicina} was higher, although the total protein production (kg.tree\(^{-1}\)) was about the same for both species.

The average soil moisture content at various depths (0–210 cm) at the end of the dry season in the experimental plots is given in Figure 6. The data imply that at the end of the dry season some water reserves still exist in the soil profile. The lowest values at this time were found at the 60–90 cm depth.

Discussion

This paper describes the first stage in a long-term project designed to assess the feasibility and economic viability, mainly for developing countries, of producing fuelwood and fuelwood plus other products, e.g. fodder or food — in an arid or semi-arid
Figure 4. Average gross calorific values (kJ.g\(^{-1}\)) of different tree components of *Eucalyptus occidentalis* and *Acacia salicina* according to cutting rotation (the range of SD is ± 0.1–0.3).

Figure 5. Digestibility (%), protein content (%) and protein level (kg.tree\(^{-1}\)) of the leaves of *Eucalyptus occidentalis* and *Acacia salicina* according to cutting rotation (S.D. values were less than ± 1.1% for the rate of digestibility and less than ± 0.6% for protein content).
area, using a rainfall-harvesting system. The advantages of rainfall-harvesting systems can be briefly summarized as follows: energy and capital investment requirements are low, and maintenance is simple. To the best of our knowledge, no such research has previously been undertaken in the context of fuelwood and fodder production in a rainfall-harvesting system.

Eucalyptus occidentalis and Acacia salicina, the species used in this work, were selected as promising candidates for fuelwood plantations based on their growth rates in other parts of Israel (Aronson et al. 1984; Weinstein 1985; Zohar, 1974a, b), high regrowth rate after coppicing (Zohar et al. 1978), and high resistance to drought (Aronson et al. 1984; Karschon and Kaplan, 1981; Zohar, 1974b). Eucalypts are considered as a promising source of biomass for energy in other parts of the world (F.A.O. 1979, Livingston and McNeill, 1973), while acacia is used as a source of biomass both for energy and for fodder (Hall, 1972).

The growth rate of the two species (Table 1) compared favourably with those trees of these species grown in other nearby sites in the northern Negev without a rainfall-harvesting system, as reported by Aronson et al. (1984), Weinstein (1985), Zohar (1974b), and Zohar and Moreshet (1987).

The relative amount of leaves in the total oven-dried biomass (Table 1) was quite high in the 2-year rotation and decreased with longer rotations (3 or 4 years). Since one of the goals of this long term project is to determine the optimal management of the cutting rotation, we compared different aspects involved in the short rotation of 2 years with other alternatives. The 2-year rotation enabled the tree to reach the optimal size for fuelwood (diameter of 5–10 cm) for daily maintenance. Likewise, a higher percentage of leaves was maintained as an energy source in the case of Eucalyptus and as a fodder source in Acacia. The gross calorific value of E. occidentalis leaves is much more than that of its woody components and significantly higher than that of the Acacia leaves (Fig. 4). The latter was found to be rich in protein content (Fig. 5).

One of the disadvantages of the 2-year rotation was the relatively low yield; the sum of the total biomass of the first and the second 2-year rotations was less than the first 4-year rotation, for both species (Table 1). However, the total biomass was increased from the first to the second rotation. Thus, the yield data reported here may in fact represent lower than average potential yield for these two species when considered over a long term period.
The experimental plantations discussed here were planted at a relatively low stocking density of 5 x 5 (400 trees ha\(^{-1}\)), such as used for long rotation fuelwood production and for recreational plantations. Therefore, all data in this work are presented in terms of trees rather than of area. In subsequent experimental plantings at the Wadi Mashash farm, the planting density was increased to 700 and 1400 trees ha\(^{-1}\) (Zohar, Aronson and Lovenstein, 1987). It seems that greater densities under short rotation reduce energy yields per tree but increase the yields per unit area (Zohar, Lovenstein and Aronson, 1988).

When interpreting our data, one should take into consideration the fact that both the overall rainfall and, more critically, the number and size of floods under the conditions prevailing at the site, are extremely variable in any given period (Figs. 2, 3). In spite of this variation, soil water moisture data from the 0–210 cm soil depth are values which might cover the trees' consumption during the dry season (Fig. 6), although some additional water may be used by the trees at deeper layers (Stibbe, 1975). The lowest recorded soil moisture content in this period appeared at a soil depth of 60–90 cm. This suggests the possibility to introduce an annual intercrop between the trees, in conformance with the agroforestry concept, in order to benefit from the remaining moisture at 0–60 cm. Preliminary data obtained in other field trials at Wadi Mashash, where soil moisture depletion is carefully monitored through an extensive network of neutron access tubes, support the integration of agroforestry under rain water harvesting conditions (Zohar et al. 1988).

The level of water which was available for tree growth led to impressive biomass yields in comparison with other plantations in Israel which were irrigated during the first year after planting and where more favourable climatic conditions prevail (Zohar, 1988). According to our present data (Table 1), the mean total fresh biomass was roughly 30
kg. y\(^{-1}\). tree\(^{-1}\) for *E. occidentalis* as calculated for the first and second rotations of 2 years and for the first rotation of 3 years; under the 4-year rotation the yield reached almost 60 kg. y\(^{-1}\). tree\(^{-1}\). For *A. salicina* the yields were 25 kg. y\(^{-1}\). tree\(^{-1}\) for 2-year rotation and approximately 30 kg. y\(^{-1}\). tree\(^{-1}\) under the 4-year rotation. According to Chittenden and Breag (1980), the mean annual consumption of fuelwood in developing countries is approximately 1.25 tons (FW) *per capita*. Assuming this estimate to be reasonably accurate for arid and semiarid regions, we can draw some interesting relationships. From the data in Table 1, we can conclude that a family of five would require annually as a source of fuel the equivalent of about 200 trees of *E. occidentalis* in a 2-year rotation and of 100 trees in a 4-year rotation. For *A. salicina*, the relevant figures would be 250 trees in a 2-year rotation and 200 in a 4-year rotation.

Assuming a stocking density of approximately 1000 trees.ha\(^{-1}\) and energy yields per tree roughly equivalent to the yields obtained in this experiment, and a rotation cycle of 2 years, a rural family would need a total area of roughly 0.4 ha of *E. occidentalis* or 0.5 ha of *A. salicina* to supply its annual demands for fuelwood.

In conclusion, the Wadi Mashash experimental farm is typical of a loess soil farm in arid and semiarid zones of Israel, as well as many other parts of the world (Evenari *et al.*, 1975, 1981). The results obtained here can be considered applicable and potentially transferable to other areas with similar climatic and edaphic conditions.

**Acknowledgements**

The continued support of the Hillson Foundation and of Mr. M. Kennedy and Mr. Gerald Leigh to the Desert Runoff Farms is gratefully acknowledged. We also thank the German-Israeli Fund for International Research and Development for their support, and J. A. A. acknowledges the support of the Clifford M. Hardin Endowment Fund, a project of the Fund for Higher Education. Thanks also to the Jewish National Fund for providing some of the tree seedlings. Hashuva Turgeman, Saadia Tzabari, Yossi Goldstein, Ofer Hornik, Simon Furnivall and Arthur du Mosch rendered invaluable field assistance.

Arie Rogel designed and built the limans, and has directed their maintenance and recorded the meteorological data at the Farm since its inception. Finally, Prof. Michael Evenari, principal founder of the Avdat, Shivta and Wadi Mashash farms, is a continuing source of inspiration.

**REFERENCES**


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LONG—ROTATION, HIGH VALUE TREES: AN ALTERNATIVE STRATEGY FOR PRIVATE FORESTRY

By P. HOARE* and N. PATANAPONGSA**

SUMMARY

The assumption is often made by social forestry planners that farmers are only interested in short-rotation forestry. However, the recent history with teak (Tectona grandis) in North Thailand shows that farmers are showing increased interest in planting teak on private lands as a cash crop, or the planting of a few trees in “niches” on smallholdings as a contingency or “bank account”. Farmers can propagate their own seedlings, and often obtain higher growth rates than in forestry plantations due to better sites, and better maintenance. The main constraint to further private development of teak is farmer uncertainty over forestry regulations concerning the cutting and transportation of teak.

RESSUMÉ

Les planificateurs des forêts collectives présument souvent que les agriculteurs ne s’intéressent qu’à la sylviculture à courte rotation. Pourtant, les expériences récentes avec teck (Tectona grandis) dans le nord de la Thaïlande montrent que les agriculteurs s’intéressent de plus en plus à la plantation de teck sur des terres privées comme culture de rapport ou la plantation de quelques arbres dans des ‘niches’ sur des petites fermes comme ‘caisse de prévoyance’. Les agriculteurs peuvent propager leurs propres semis, et ils obtiennent souvent des meilleurs taux de croissance que dans les plantations forestières à cause de meilleures stations et meilleur entretien. La contrainte principale à l’extension du développement privé de teck est l’incertitude des agriculteurs en ce qui concerne les règlements forestiers sur l’abattage et le transport de teck.

RESUMEN

Los planificadores en el campo social de la silvicultura, generalmente asumen que los agricultores se interesan únicamente en la silvicultura de rotaciones cortas; sin embargo, la historia reciente con teca (Tectona grandis) en el norte de Tailandia, muestra como los agricultores se están interesando cada vez más en plantar teca en tierras privadas como una fuente de ingresos, o en plantar algunos pocos árboles en minifundios como contingencia o “cuenta bancaria”. Los agricultores pueden propagar sus propias plantas y generalmente obtienen tasas de crecimiento más altas que en plantaciones forestales, debido a mejores condiciones del sitio y mejor mantenimiento. La principal limitante para un mayor desarrollo privado de la teca, es la inseguridad del agricultor acerca de las leyes forestales que conciernen el corte y transporte de teca.

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** Professor, Extension Department, Faculty of Agriculture, Chiang Mai University

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Introduction

An assumption often made by government policy makers and forestry project planners is that farmers are only interested in short-rotation forestry where the tree products can be harvested for fuelwood or other uses in from three to seven years. However, the hypothesis of this paper, based on the recent history of teak (Tectona grandis) in Northern Thailand, is that long-rotation forestry with high value tree crops may be an alternative strategy for some private landowners and, on a limited scale, even for community forestry projects.

The annual rate of deforestation in Thailand is 333,000 ha per year, second only to Indonesia in the Asia Pacific Region (Royal Forest Department 1985, a), (FAO, 1985). The rate of government reforestation is only about one-tenth of the rate of deforestation (FAO, 1986 a).

The proportion of landless farmers in Thailand is only 1.5%, and the percentage of farmers renting land is 5.5% (National Statistics Office, 1983). Hence the emphasis on Private forestry. This need to involve the private sector in reforestation has been recognized in Thailand in both the Fifth National Development Plan (FAO, 1984) and in the National Forest Policy of the Royal Forest Department (RFD 1985).

Most of the plantings by the private sector have been with Eucalyptus camaldulensis in the Central and North-East Regions of Thailand, where the remaining forest areas are only 26% and 14% of the land area respectively (BP, 1986). There are two factory outlets, one at Bang Nga on the seaboard and one at Khon Kaen in the North East. There are domestic markets near the large towns some wood chips and pulp are exported to foreign countries. The Khon Kaen factory is experimenting using eucalypt wood in place of bamboo as the latter is now in short supply. In the Upper North of Thailand, there has been less planting of eucalypts due to the relatively low price of fuelwood in rural areas and the slower growth rates of Eucalyptus camaldulensis with the lower temperatures.
Teak in Thailand: from Exporter to Importer

"Locally called “Sak”, teak is the best known, most universally used and most valuable timber tree of Thailand. It is by law a specially reserved tree which cannot be used without permit, no matter where grown" (Mahaphol, 1954).

In Northern Thailand teak is found in the mixed deciduous forest at altitudes between 100m and 900m above sea level, and between latitudes 14°N and 20°N (Donner, 1978).

The average annual wood production in North Thailand between 1961 and 1970 was 123,646 m³ of roundwood teak, 177,631 m³ of roundwood non-teak, 125,275 m³ of firewood and 15,669 m³ of charcoal (Donner, 1978; based on Royal Forest Department data).

While Thailand was once an exporter of teak, at present it is a net importer. In 1985, the official figures show that 39,000 m³ of teak valued at (US)$ 27,000,000 were imported.

The problem of the depletion of the teak forests dates back to the 1874 and 1883 Chiang Mai treaties concluded under British pressure (Ganjanapan, 1984). These treaties forced the Siamese (Thai) government in Bangkok to guarantee British investment in the cutting and trade in teak in the North. As a result, large quantities of teak were exported under these agreements causing considerable areas of teak forests to be decimated both legally and illegally.

The illegal cutting of teak was estimated to total 2,100,000 m³ between 1957 and 1968, which was greater than the total official production of 1,900,000 m³ over the same period (Soho, 1974). The reasons given by Ganjanapan for the more recent deforestation and depletion of teak in North Thailand are:

a) the expansion of rice production and cash crops in forest land with the population increase after World War 2;
b) the demand from forest industries based on teak, teak products and wood carving;
and
c) the increasing demands for fuelwood by light industry, particularly tobacco curing (Ramitanondh, 1985).

The Social Silvicultural and Economics Aspects

Social Aspects. The preferred Northern Thai life style is closely associated with teak. Most people would like to live in a teak house, but today few can afford this luxury. Teak furniture and a teak coffin are status symbols.

Most farmers believe that teak requires up to 60 years to mature and that areas reforested with teak are a sign of government land tenure. As teak becomes scarcer and more expensive, the theft of teak trees from government plantations becomes a more serious problem. “In the first reforestation project, eight out of ten plantation units reported that 204 teak trees, at the age 10–15 years and sizes at girth at breast height (gbh) 75–100 cm, were stolen. It has become a big problem to protect the teak trees in the plantation from theft in order to let them grow and reach their size limit for cutting in a 60 years rotation” (Kaosingha, 1982). However, farmers generally do not steal from their neighbours whereas they may steal government property.

Silvicultural aspects. Teak seeds mature at the end of the dry season in March or April and are planted on a seedbed at the beginning of the rainy season in May. After 12 months in the nursery, the seedlings are ready for transplanting.

Bare-rooted “stumps” are used for planting with the top cut back to about 2.5 cm above the collar, leaving two buds and an underground “carrot like” stump about 21 cm in length (Mahaphol, 1954). Royal Forest Department nurseries and naturally
regenerating teak are currently the source of seedlings for farmers, but the propagation could easily be done by farmers with a little training.

The planting time is between April and June. A spacing of 4 m × 4 m (625 trees/ha) is generally used. The growth rate of teak may be substantially increased in the first two years by careful weed control and the addition of small amounts of fertilizer. Good weed control may be achieved with annual cropping between the teak trees on the taungya system. This weed control, together with the application of a spoonful of NPK fertilizer
Plate 3. Teak stumps 6 months after transplanting. A fertile site, the trees being ring weeded and fertilized three times.

(about 25 gm per tree) can result in a doubling of the growth rate in the first year (Wong, 1986). The cost of the fertilizer is only about US$3/ha for one application.

Generally, teak sheds its leaves in the dry season and fire control is important in the first dry season when the seedlings are small. Forest fires occurring after the first dry season generally do little damage to teak. After teak is about five years old, it can be coppiced. The branches of teak make good fuelwood. The continuation of careful weed control in the second and third years by intercropping, or careful ringweeding, can result in significant growth increases.

Thinning is usually carried out at year seven and then every five years (Mahaphol, 1954). There are some insect pests, such as the bee hole borer (Duomitus caramicus), but generally they are not a serious problem.

Evidence indicates that by applying silvicultural practices there may be considerable potential for achieving faster growth rates with teak than the average achieved in government plantations. This is due to the limited government budget for maintenance of plantation and dry season fire control, which is about US$250/ha during the first five years. As the case studies below indicate, on favourable sites, growth rates of 150 cm girth at breast height should be achievable within 25 to 30 years by farmers using improved silvicultural practices. At present, 150 cm gbh is the minimum legal size for cutting teak in Thailand.

Economic aspects. Teak increased steadily in price during the past decade. The price trends indicate that the price differential between teak and the fast-growing species such as eucalyptus may continue to increase.

Teak thinnings of size 50 cm gbh now have a value of about 1000 baht/m³ (US$40), the price increases to 3,000 baht/m³ (US$120) at 75 to 100 cm. gbh and 10,000 baht/m³ (US$400) for a size of 150 cm to 180 cm gbh (Sawickamin, 1986).

A single teak tree with good management on a good site may achieve a gbh of 150 cm to 180 cm in 25 to 30 years, and such a tree may yield up to 1 m³ of timber. Thus one tree on a favourable site could gross US$400. One or two trees could fit the social forestry
strategy of using trees to meet rural household contingencies. (Chambers and Leach, 1987).

After the final thinning of a private teak plantation on a good site, there would be about 125 teak trees/ha with a potential gross in 25 to 30 years of about US$50,000.

Plate 4. 40 year old teak (*Tectona grandis*) at Chiang Mai worth over US$ 500.

Case studies of Private Forestry in Uttaradit Province

Uttaradit in North Thailand is one of the most interesting areas of Thailand for the development of both fruit and forest tree farming by the private sector. Locally developed varieties of durian and langsat are important crops which fit particular ecological niches; forest tree farming is a growing enterprise. Three farmers planting eucalyptus and teak as a cash crop were interviewed.

*The Eucalypt Farmer* Mr. Wichai Kitchaijarern is the owner of the Chai Fah Hotel and of a water bottling plant. He purchased 96 hectares of upland land and started planting eucalypts on poorer soils not suited to teak. He is gambling on a pulpwood factory being established within 300 Km of Uttaradit within the next five years for he feels that the sale of eucalypts for fuelwood is not an economic proposition at current prices.

He purchased the 96 ha of upland at prices from US$240 to US$480/ha along the highway. At first he rented the land out to farmers but he considered that the annual rental fee of only $25/ha was not sufficient to cover his management costs.

He decided to plant eucalypts following the Royal Forest Department (RFD) public relations campaign, and produced his own seedlings. The initial planting was 8 ha. The area was relatively flat so the cultivation could be done by contract tractor. Soybean was intercropped in the first two years. The soybean yield in the first year was about 940 kg per ha., and the sale price about 6 baht per kg. The first year gross from soybean was US$217/ha., and in the second year the soybean yield was lower due to competition from the eucalypts. The input into weed control was much greater than in RFD plantations.

Fertilizer (15:15:15– NPK) was applied three times in the first year and three times in the second year. The amount was only about 37.5 kg/ha in the first year at a cost of US$9 and US$14/ha in the second year. No fertilizer was applied in the third and subsequent years.
Fire control, achieved through rotary hoeing at the end of the wet season cost US$17/ha. The rotary hoe is much more effective and cheaper than hand labour.

Mr Kitchijarern expects a market price of US$4 per eucalypt tree in a five year rotation. This price would gross US$2,500/ha in the fifth year. However, this return is dependent on a factory being established. If the factory is not established then he expects that the returns from sale of fuelwood will be much lower.

Both Mr. Kitchaijarern and the Provincial Forester Mr. Sawichamin agree that farming eucalypts is not a business to recommend to small holders with limited capital and land resources in this market situation. They consider that an area of about 100 ha is needed for a 7 to 10 year rotation and that a steady income from other enterprises is needed during the first ten years until the venture yields regular income.

The Teak Farmer Mr. Pilah Mookarwat has a relatively large farm of 34 ha. of paddy orchard and upland area. The RFD Provincial Officer gave him two basketfuls of teak stumps 27 years ago and suggested that he plant them on his upland area. Mr. Mookarwat planted the teak and carried out some weeding in the first two years but then forgot about the trees.

Fortunately, the teak is resistant to fire and it grew well without maintenance. There are now about 200 trees with a girth of 160 cm or more. Mr. Mookarwat has been offered US$385 per m$^3$ at the farm gate by a private contractor for the large trees. The Provincial Silvicultural Officer considered that there would be at least one cubic metre of teak in the trees of 160 cm girth. This puts their present value at around 2 million baht or US$77,000 for the 200 trees. The owner plans to let contractors harvest the timber in 1988. His children will be the beneficiaries of the teak sale.

If he realizes the 2 million baht teak harvest, interest in growing teak as a cash farm crop is bound to increase in Uttaradit and other provinces in North Thailand.

The teak farmer Mr. Lamoon Dongluang is about 45 old and has 3.5 ha. of paddy land and 1.6 ha. of upland area. He is planting the upland portion to teak for his children and grandchildren. He had already planted 300 stumps of teak from the Uttaradit central nursery in July 1986. Using his 11 horse-power all purpose machine, he was able to transport more stumps back to his farm. The same engine can be used for land preparation, weeding, and fire control in his teak plantation.

He is planting at 2 m x 2 m spacing (2,500 trees/ha) and aims to plant 0.3 ha/yr over the next five years. One worry is possible theft of the teak so, he is planting as close to the house as possible.

Teak is also being planted by two small Non-government projects in Chiang Mai and Lampoon Provinces (Rao, 1986).

There appears to be considerable interest by the private sector in North Thailand in planting teak. There would probably be much greater interest if the legal aspects of planting teak were clarified and adequate information disseminated to farmers.

Legal aspects

At present there are many forestry regulations which affect the cutting and transport of teak on both Government and private titled lands. Many of the regulations are difficult to interpret due to the large number of amendments (RFD, 1982). There are special forestry regulations which apply to teak and *Dipterocarpus* spp. but not to exotic species such as eucalypts and leucaena.

For example, if a farmer wishes to cut teak trees on his own titled land, there are a number of regulations which apply:

a) the farmer must first make an application to the District Forest Officer. A committee composed of a representative from the Land Department, Local
Administrative Department and RFD will be appointed to inspect the teak trees and ascertain whether they are on titled lands and have gbh of 150 cm or greater. The amount of teak to be cut in relation to the stated purpose, e.g. house building, is also assessed.

b) the District Committee then report its findings and process the paper work to the Provincial level.

c) if the proposal to cut the teak is approved at the provincial level, it may then require approval of the Director-General of the RFD if a large amount of teak is involved.

After teak trees are cut, a RFD Officer needs to stamp the logs. Permission is also required to transport the logs across each district and provincial boundary. During the transportation, many authorities can check and inspect the teak.

These regulations could impose considerable constraints on the cutting and transport of teak, in particular if the farmer wants to thin his teak on private land or wishes to harvest before the gbh is 150cm. A simplification of these procedures is required in order to encourage the planting of teak in private forestry and social forestry.

**Recommended Changes in Forestry Policy**

The local supply of teak and other high value timbers is becoming so limited in Thailand that the problem of illegal logging from the remaining reserved forest areas and Government plantations is bound to increase and as noted before, in 1985, a total of 39,000 m$^3$ of teak valued at US$27 M was imported.

The two strategies suggested by the authors to help alleviate this problem are 1) more effective enforcement of the protection of reserved forest areas and, 2) government encouragement of private plantings of high value trees on titled lands.

There are already enough forest regulations in place, and probably enough forestry and local government officers to minimize the theft of high value trees from Government lands.

The attitudes and consistent support of high ranking government officers as well as public involvement, are most important for enforcement. At present, the Minister of Agriculture is paying close attention to this matter and is taking strong action to protect forests (*Bangkok Post* 1987). Forestry officials who do not enforce the law and regulations are subject to investigations by a special committee, set up by the Ministry of Agriculture. Officials found to have neglected or failed to perform their duties are either transferred or punished by fine (depending on the severity of the offence). Because of the resulting publicity the Minister is receiving many reports from the rural population of alleged violations of forest laws.

The following measures could further help with the enforcement of forest law:

a) the establishment of a private mail box where the Minister could be be informed by the public of possible violations

b) the offering of reward to individuals who provide evidence of theft of timber from government plantations, and

c) rewards to rural communities adjoining reserved forest lands and Government plantations for co-operation in the maintenance and protection of forest areas.

Equally important for the more effective policing of Government lands is the long-term strategy to encourage the planting of high value timber by the private sector on titled land. This could be achieved by the following measures:

a) a clarification that under the existing forest laws, the harvesting of teak and other high value tree crops on private titled lands is legal, and the dissemination of this information to farmers;
b) an increased supply of teak "stumps" for distribution to farmers from RFD nurseries and the dissemination of information on the propagation and maintenance of teak plantations; and
c) the reduction and gradual elimination of the regulations governing the cutting and transport of teak from private lands as the policing of reserved forest areas and Government plantations improves.

**Suggested Strategies for Promoting Private Plantings of teak**

The following strategies are suggested for planting teak on private land, and in public places in towns:

**Resource-rich farmers**

The case studies show that farmers with above average titled land holdings and suitable sites are prepared to invest in teak as a long-rotation high value cash crop. The taungya system provides the most effective system for weed control and some income in the first two years. These farmers would, of course need to have sufficient income from other businesses to support their families before the harvest of teak.

**Resource-poor farmers**

Farmers with titled land holdings of less than 2 ha may be able to find sites around the house compound, or along boundary lines, where theft is not a problem and they can plant from 5 to 20 teak trees. There appears to be potential for teak planted at low tree density in agroforestry systems, such as in longan and mango orchards. At present, the planting of teak on land without a relatively secure title is not recommended, as it could not be harvested legally.

**Public areas**

_Eucalyptus camaldulensis_ has replaced teak for planting around many government buildings in North Thailand. It is suggested that teak would be a suitable choice on better sites near population centres.

**Conclusion**

In the Central and North-East Regions of Thailand, where the remaining forest area is limited and there is a good market for fuelwood, the private sector forestry is based on short-rotation trees such as _Eucalyptus camaldulensis_.

The case studies from North Thailand, which contains half of the Kingdom’s remaining forest area, show that some businessmen and farmers with above average resources of land have planted teak as cash crop. If the present steady increase in the price of teak continues and the forestry regulations governing the cutting and transport of teak from private titled lands are changed, then the area planted by the private sector to teak will probably increase substantially.

This strategy of planting high value, long-rotation timber trees through private forestry has also been suggested by forestry officers in Papua New Guinea and the Philippines during a field evaluation of agroforestry and social forestry programmes (Hoare, 1986).

In Madang Province of Papua New Guinea (PNG), the policy of the Department of Forests is to promote the planting of _Eucalyptus deglupta_ by smallholders in a eucalypt/cocoa agroforestry system. The objective is to provide timber for the pulp factory at
Madang for export and income from cocoa. One Forest Research Officer considered that the planting of slower growing high value PNG timbers could be an alternate strategy for smallholders. (Skelton, 1986)

In the Bicol region of the Philippines, the Regional Bureau of Forests believes that the planting of mahogany as a cash crop is becoming economically more attractive as the remaining resource of forest mahogany in the Philippines is rapidly decreasing (Batcagan, 1986).

We believe that the examples presented in this paper show that long-rotation, high value trees should be considered as an alternate strategy when planning private sector and social forestry projects.

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ROOT DISEASE (PHELLINUS NOXIOUS (CORNER) G. H. CUNN.) OF CORDIA ALLIODORA IN VANUATU

By P. E. NEIL*

SUMMARY
Since the early 1970's, Cordia alliodora has been widely planted on various islands throughout Vanuatu. However, the species has suffered from a root disease, Phellinus noxius, which has caused significant losses in some plantations. Field investigations were started in 1983 which involved a comprehensive survey of all plantations. A follow up survey was carried out in 1985 and a number of observation blocks and trials established. The investigations showed that site conditions were related to the incidence of root disease, and that some native tree species were carriers of P. noxius and potentially important field centres of infection. Precipitation is also thought to play a role in the incidence of root rot. Likewise, it is apparent that extremes of weather, such as experienced during a hurricane, are of considerable importance in serious root rot outbreaks.

Investigations into the disease are continuing involving modification of methods of clearing the natural forest to reduce the residual inoculum in the soil, the use of "blocking plants", and the possible use of less susceptible provenances of C. allidora or tree species in plantations. Currently, careful site selection is the most cost-effective management of the disease.

RESUME
Depuis le debut des annees 70 Cordia alliodora a ete planté sur une grande étendue sur des iles diverses du Vanuatu. Pourtant, l'essence a ete atteinte d'une maladie des racines, Phellinus noxius, qui a entraîné des pertes considérables dans quelques plantations. Des enquêtes sur le terrain ont été commencées en 1983, qui comprenaient une étude complète de toutes les plantations. Une étude complémentaire a été réalisée en 1985 et quelques blocs d'observation et essais ont été établis. Les enquêtes ont montré qu'il y avait un rapport entre les facteurs du milieu et la fréquence de la maladie des racines, et que quelques essences forestières indigènes étaient des plantes porteuses de P. noxius et des foyers potentiellement important d'infection sur le terrain. La précipitation peut aussi influencer la fréquence du pourridie Pareillement, il est évident que les extrêmes du temps, comme dans un ouragan, sont d'une importance considérable dans les recrudescences graves du pourridié.

Des enquêtes sur la maladie se poursuivent, entraînant la modification des méthodes de dégagement de la forêt naturelle pour réduire l'inoculum restant dans le sol, l'utilisation de 'plantes bloquantes', et l'utilisation éventuelle de provenances moins susceptibles de C. alliodora ou des essences moins susceptibles dans les plantations. Actuellement, le choix soigneux de sites est la méthode de gestion la plus rentable de la maladie.

RESUMEN
Cordia alliodora se ha venido plantando extensivamente en varias islas de Vanuatu desde principios de la década de los setenta. Sin embargo, la especie ha sufrido del

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ataque de una enfermedad de la raíz, *Phellinus noxius*, la cual ha causado pérdidas significativas en algunas plantaciones. En 1983 se iniciaron investigaciones de campo, las cuales incluyeron un inventario de reconocimiento detallado de todas las plantaciones. En 1985 se llevó a cabo un segundo inventario de reconocimiento y se establecieron una serie de bloques y ensayos de observación. Las investigaciones mostraron que las condiciones del sitio están asociadas con la incidencia de la enfermedad y que algunas especies nativas son portadoras de *P. noxius* y potencialmente importantes fuentes de inóculo. También se cree que la precipitación juega algún papel en la incidencia de la pudrición de raíz. Igualmente, parece que condiciones climáticas extremas, tales como el efecto de huracanes, son de considerable importancia en el inicio de la enfermedad.

Las investigaciones sobre la enfermedad continúan, las cuales incluyen una modificación de métodos de limpieza del bosque natural a manera de reducir el inóculo residual en el suelo, el uso de “plantas de bloqueo” y el posible uso en plantaciones de procedencias de *C. alliodora* u otras especies menos susceptibles. Actualmente, la selección cuidadosa del sitio es la acción de manejo más efectiva en términos de costo.

**Introduction**

The natural forests of the islands of Vanuatu are generally poor in tree species of commercial value and their improvement by enrichment planting or the establishment of plantations of exotic species is now an important aspect of national forest development. Since its introduction in 1972, *Cordia alliodora* (R. & P.) Oken has proved to be superior in quality and increment to over fifty other introduced species that have been tested in Vanuatu (Neil, 1983a) and to date some 1250 ha have been planted on twelve of the islands (Fig. 1).

The silviculture that has been most widely used (Hudson, 1984) is based on lines cut at 10 m intervals through the natural forest. Where the lines encounter non-commercial forest trees, these are removed either by felling, poisoning or burning. The cut lines are then planted at 2.5 m intervals with seedling stumps obtained from natural regeneration. Where secondary bush is to be planted, an espacement of 5 m x 5 m is used. Both planting systems are expected to produce final crop trees of 35 m height and 55 cm d.b.h. in twenty years. There are prospects that the present tree improvement programme (Neil, 1987b) may lead to further improvements in the productivity of this species in Vanuatu.

Although *C. alliodora* has many features that make it ideal for the improvement of forest resources in Vanuatu, it has been found to be susceptible to the native soil fungus *Phellinus noxius* (Corner) G. H. Cunn. This root rot was originally observed on *C. alliodora* on the island of Espiritu Santo and has since been found on all islands where *C. alliodora* has been planted (Gibson, 1982; Neil, 1986). Field surveys and experiments on the problem were started in 1983 and continue to the present. This article is a discussion of the results from both general observations and from formal field trials to date. It is a sequel to an earlier publication (Neil, 1986).

**Symptoms and Etiology**

The symptoms of *Phellinus* root disease of *C. alliodora* in Vanuatu have been described in previous publications (Gibson, 1982; Neil, 1986) and conform with descriptions from elsewhere (Pegler & Waterson, 1968; Añon., 1974; Sujan Singh et al., 1980; Turner, 1981; Gibson, 1982; Mallet et al., 1985). Initial symptoms appear as a chlorosis followed by leafcast, and at this stage parts of the lateral root system near the soil surface may be found encased in a brown fungal sheath, in which fragments of soil and stone are embedded. Later, a fungal sheath will appear, encasing the base of the stem above the
root disease in *Cordia alliodora*.

By this stage the tree may well be dead. In *C. alliodora*, recovery does not occur after the first symptoms appear. The characteristic brown bracket sporophores, which provide confirmation of the identity of the pathogen may, but do not always, appear on the stems of infected trees at these later stages (Pegler & Waterson, 1968). The field distribution of infected trees is patchy (or grouped in line-planted trees), providing evidence that the disease arises in *C. alliodora* in Vanuatu from inoculum in the soil and is transmitted in this way. There is no evidence of spread between cut lines (10 m) unless there is an intervening host or stump, but spread can take place between trees at 5 m spacing. No evidence has been found of infection of stem lesions by airborne spores, such as occur in some other hosts (Turner, 1981).
In early studies of the disease in *C. alliodora* all diagnosis was based on field symptoms and comparison of cultures from diseased trees with those of *P. noxius*. These comparisons were carried out by Dr. L. Bolland* who has also identified encrusting mycelium and sporophores from forest trees as *P. noxius*. However, no collection of the sporophores of this fungus have ever been found on *C. alliodora* in Vanuatu. Table 1 lists species identified as being *P. noxius* hosts.

*P. noxius* occurs in tropical rainforest throughout the world and is known as a serious pathogen on herbaceous plants, shrubs and trees from almost 50 genera and over 20 families of gymnosperms and angiosperms (Bolland, 1984). It occurs throughout the Pacific where it can cause serious losses to oil palm, rubber, forest crops and other crops established on cut-over forest sites where relic stumps and roots provide sources of inoculum (Gibson, 1982; Hodges & Tenoria, 1984; Smith, 1985; Sujan Singh et al, 1980; Turner, 1981). Mallet *et al* (1985) discuss a similar incidence of *P. noxius* in West Africa.

### Table 1

Species known to be hosts or killed by *Phellinus noxius* in Vanuatu.

<table>
<thead>
<tr>
<th>Indigenous</th>
<th>Exotics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agathis macrophylla*</td>
<td>Araucaria cunninghamii</td>
</tr>
<tr>
<td>Antiaris toxicaria*</td>
<td>Cajanun cajan</td>
</tr>
<tr>
<td>Artocarpus atilis</td>
<td>Cedrela odorata</td>
</tr>
<tr>
<td>Callophyllum neo-ebudicum*</td>
<td>Cordia alliodora*</td>
</tr>
<tr>
<td>Carica papaya*</td>
<td>Gliricidia sepium</td>
</tr>
<tr>
<td>Delonix regia</td>
<td>Gmelina arborea*</td>
</tr>
<tr>
<td>Dendrocnide sp.*</td>
<td>Erythrina indica*</td>
</tr>
<tr>
<td>Dracontomelon vitienis</td>
<td>Erythrina variegata*</td>
</tr>
<tr>
<td>Erythrina indica*</td>
<td>Ficus septica</td>
</tr>
<tr>
<td></td>
<td>Garuga floribunda*</td>
</tr>
<tr>
<td></td>
<td>Hibiscus tiliaceus*</td>
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<tr>
<td></td>
<td>Metroxylon sp.*</td>
</tr>
<tr>
<td></td>
<td>Myristica fata*</td>
</tr>
<tr>
<td></td>
<td>M. fata var. papuana*</td>
</tr>
<tr>
<td></td>
<td>Osmoxylon occidentale*</td>
</tr>
<tr>
<td></td>
<td>Veitchia spp.</td>
</tr>
</tbody>
</table>

*Isolates or fruiting bodies collected and formally identified as *P. noxius*.

**Field Investigations**

A comprehensive field survey of all planted *C. alliodora* for losses from *P. noxius* was carried out throughout Vanuatu in 1983. It was followed by a similar survey in 1985 in which 20% of each stand was sampled at random by rows. For scoring, notes were kept on the survival, health, and vigour of each tree, with details, which were marked on the plot chart. Notes were also kept on the sources of infection and, where possible, their identity. In areas where the incidence of *P. noxius* attack was high, intensive observation plots were established at a range of ages and scored at 3-5 month intervals, providing more detailed information on the rate and pattern of spread.

* Biology Section, Division of Technical Services, Queensland Forest Department, Australia.
The results of the survey are shown in Table 2, and the more detailed plots in Fig. 2. Certain experiments were severely damaged and compromised during the 1985 hurricane period, particularly those to evaluate the effect of clearing methods on residual inoculum (including arboricides). Similarly, hurricane damage and the subsequent rehabilitation of plantations seriously reduced the value of certain parts of the second survey (Neil, 1985).

### Edaphic, Vegetational, and Climatic Effects

The survey results showed that the site conditions were related to the incidence of *P. noxius* attack on *C. alliodora*. In general, the soils of the islands are good (Stevens, 1987) but on some sites, such as Lemalda on Pentecost Island, the soils are severely leached (Neil, *et al.*, 1985). *C. alliodora* grows poorly and incidence of disease is abnormally high. However, this may not reflect a simple relationship between inferior soil conditions, poor host vigour and associated reduction in resistance to attack, as increased incidence of *P. noxius* attack has been found to be related to the presence of certain native forest trees, which may act as carriers of the fungus. During survey and other field studies it was often noted that fungal mats, similar to those formed by *P. noxius*, were to be found associated with the lateral roots and base of the bole of certain tree species. These mats have been sampled and sent to Dr. Bolland for cultural identification and as a result, certain native forest trees have been identified as carriers of *P. noxius* and potentially important field centres of infection (Table 1). *Myristica fatua* and *Myristica fatua var. papuana* have emerged as possibly the most important of these carriers in Vanuatu, and it is suggested that the high populations of these taxa that are found in the Lemalda region of Pentecost also contributed to the high incidence of *P. noxius* attack there, in addition to the poor soils. Meterological observations in Vanuatu have been limited; synoptic stations are evenly distributed throughout the country, but confined to the coastal zones. As a result there is little detailed information about the high altitude regions, although it is known that there is much variation in these regions, due to aspect and rain shadow effects. There is an overall decrease in annual precipitation from the north to the south of the island group. It has become apparent from the results of the two surveys that there is a general decrease in incidence of *P. noxius* attack in *C. alliodora* in the same direction.

In addition, from observations of the effects of recent hurricanes on plantations and the natural forest (Barrance, 1985; Neil and Barrance, 1987; Neil, 1987), it is apparent that these extremes of weather are of considerable importance in serious root rot outbreaks. Hurricane damage to trees in the form of root wrenching and other ways of reducing resistance undoubtedly causes increased disease incidence. However, at present it is not clear whether the increase is due purely to the lowered resistance of individual trees or also to the increases in inoculum from the vast quantity of additional woody debris that is produced by a hurricane. It is thought that the *P. noxius* infection of a few *Tectona grandis* on Erromango Island is directly attributable to the trauma caused to the trees during the passage of a cyclone with winds in excess of 100 knots in early 1987. We still have much to learn about the effects of various environmental factors on the risk of attack of *C. alliodora* plantings in Vanuatu, but it is already clear that soil quality, previous site vegetation and soil moisture (or precipitation) play an important part in deciding the hazard rating for a site. With more field data it should be possible to provide a rating for the disease risk to be faced on a new planting site, based on soil quality, frequency of known carrier trees, and the “seasonal index” for soil moisture (mean rainfall for wettest month divided by mean rainfall for driest month).
Table 2


<table>
<thead>
<tr>
<th>PLANTATION</th>
<th>PLOT</th>
<th>DISEASE INCIDENCE AND AGE</th>
<th>1983</th>
<th>1985</th>
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<tr>
<td></td>
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<td>%*</td>
<td>AGE*</td>
<td>%*</td>
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<td>35.5</td>
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<td>(3.4)</td>
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<td>42</td>
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<td>0</td>
<td>42</td>
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<td>p.83</td>
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<td>-</td>
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<td>1.6</td>
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<td>-</td>
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<td>p.81</td>
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<td>0.3</td>
<td>56</td>
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<td>80</td>
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<td>0.2</td>
<td>68</td>
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<td>p.83</td>
<td>-</td>
<td>-</td>
<td>31</td>
<td>0.0</td>
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</tbody>
</table>

*Age in months; Incidence, % of original planted population. Island names are followed by approximate annual rainfall (mm) and Myristica Index (xxx >50%; xx = ca. 25%; x <25% of stumps).
Observation plot records made over the same period for two plantings of different age in the same region. Pentecost Island (high risk disease sites).

Naisu (P. 78) Plot 1

<table>
<thead>
<tr>
<th>Age: 76 months.</th>
<th>Age: 79 m.</th>
<th>Age: 88 m.</th>
<th>Age: 92 m.</th>
<th>Age: 95 m.</th>
<th>Age: 101 m.</th>
</tr>
</thead>
</table>

Plots 6 rows of 10 trees (60 trees). Espacement 10m. by 3m.

Surukavian (P. 84) Plot Ag For.

<table>
<thead>
<tr>
<th>Age: 4 months.</th>
<th>Age: 7 m.</th>
<th>Age: 10 m.</th>
<th>Age: 15 m.</th>
<th>Age: 16 m.</th>
<th>Age: 20 m.</th>
<th>Age: 27 m.</th>
</tr>
</thead>
</table>

NB. Loss figures show diseased trees with total deaths in brackets.

**Disease Ratings.**

U — Chlorotic.
S — Stag headed.
D — Dead, with signs of *P. noxius* attack.
F — Fallen, diseased.
M — Missing. Previously diseased or in a patch of disease.
“Blanks” — Healthy trees.

**NOTE.** Young plants rated U sometimes recover. Abnormally dry season in mid 1985.

### Age of Crop

Early observations on the incidence of root disease of *C. alliodora* strongly suggested that the crop was not susceptible until it was more than two years of age. It was also thought that after an age of eight to ten years, susceptibility and the rate at which the disease spread in the crop declined. However, during the last three years, both these ideas have been abandoned in the light of more complete field observations (Table 3). It is now known that seedlings as young as 10 months old can be killed by *P. noxius* (Surukavian, Pentecost), and elsewhere nine-year-old trees of up to 40 cm d.b.h. have succumbed to primary attack. The results of the surveys have shown that continuing losses in plantations can be due to contact of tree roots with fresh centres of infection, in addition to the continued activity of the soil inocula at the actual planting site. Under
Table 3
Relation of Age to *Phellinus noxius* Attack in *Cordia alliodora*.

<table>
<thead>
<tr>
<th>MEAN AGE* (months)</th>
<th>MEAN %* INCIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.6</td>
<td>2.10</td>
</tr>
<tr>
<td>25.3</td>
<td>1.81</td>
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<td>31.1</td>
<td>1.89</td>
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<td>5.09</td>
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<tr>
<td>72.7</td>
<td>6.54</td>
</tr>
</tbody>
</table>


some conditions, this could lead to an increase in the rate of loss a few years after the plantation was established, which would only fall off again when the original or early centres of infection eventually declined in their activity.

**Espacement**

It has been already noted that spread of root disease between infected and healthy trees is unlikely to take place over a distance of 10 m when the crop is less than 10 years old. At distances of 5 m and 2.5 m, spread by root contact readily takes place. Trees 10 m apart will be affected if an inoculum mass is situated between them. This is an important consideration in any review of silvicultural methods for *C. alliodora* in Vanuatu.

**Discussion and Conclusions**

Where it is at its worst, the incidence of *P. noxius* root disease on *C. alliodora* in Vanuatu has been sufficient to preclude further planting of the tree. Elsewhere, the disease has nearly always been sufficiently serious for it to warrant special measures, which may be based on the avoidance of conditions likely to favour attack or adoption of measures to reduce the activity of the fungus. However, we are not in a good position yet to do this.

The considerable effect that hurricanes have on the incidence of *P. noxius* on plantation trees is obviously important, but extremely difficult to quantify. Only close observation of trees before and after such violent weather can help to add to our knowledge and understanding.

We also need more information on the genetic variation between races of the pathogen as well as the effect of the environment on its activity. While the latter has received some local study, the value of our information depends on the assumed genetic uniformity of the pathogen. Our information so far suggests that *P. noxius* is represented by a single race throughout Vanuatu, but it is possible that beyond this, in Fiji and the Solomon Islands, there may be races differing in their pathogenicity, host range and other respects. This is a matter that needs further investigation before there can be a free exchange of information on this important disease among the different island groups in the Pacific and elsewhere. Variation between local races of *P. noxius* has been described from West Africa by Nicole *et al* (1985).
Notwithstanding this possible complication, careful site choice will always be of prime importance to produce cost-effective management of the problem in the immediate future.

Modification of methods of clearing the natural forest to reduce the residual inoculum in the soil, either mechanically by bulldozing or by arboricides is another approach that can reduce the risk of *P. noxius* attack in a subsequent tree crop. However, this approach calls for thorough field testing before being brought into practice and may prove to be too costly. Field trials of arsenic pentoxide and sodium arsenate to poison forest trees and prevent their colonization by *P. noxius* have been conducted in Vanuatu and Fiji with variable results. In Fiji both compounds were found to be ineffective in preventing the colonization of dying trees, and similar observations were made in Vanuatu. However, in a further trial in Vanuatu of two large field plots, respectively clear-cut and treated with arsenic pentoxide, and then planted with *C. alliodora* at 10 m by 5 m, the incidence of *P. noxius* was much more serious where the forest had been clearfelled than where it was poisoned. One can only conclude from this that much more study is required on the effect of arboricide treatment in clearing sites for forest planting and its effect on the inoculum potential of *P. noxius*.

The use of “blocking plants” has been investigated during the last three years. These are herbaceous species (e.g. *Plectranthus amboinicus, Coleus scutellaroides*), which are used traditionally in local “gardens” to prevent the spread of root diseases such as that caused by *P. noxius*. A collection of seeds and cuttings of these plants has been started and they will be tested in the near future to evaluate their capacity to prevent the spread of *P. noxius* between neighbouring plants. If they prove effective, they could be used as a ground cover in the same way that leguminous cover is used to protect rubber crops from root disease (Anon., 1974 a,b).

In the course of the present investigations, no evidence has been forthcoming to indicate any useful degree of resistance to *P. noxius* attack in varieties and provenances of *C. alliodora*. In this respect the species is similar to rubber, which shows no heritable resistance to *P. noxius* attack despite exhaustive field tests (Nicole *et al.*, 1985). Alternative species are available for planting instead of *C. alliodora* but all are to some extent susceptible to *P. noxius* attack. Although this susceptibility may be somewhat less than that of *C. alliodora*, this does not compensate for the inferior crop qualities of these other species. There is, therefore every justification for the continued planting of *C. alliodora* in Vanuatu and the extension of research into cost-effective management of losses due to root attack by *P. noxius*.

**Acknowledgements**

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**REFERENCES**


HERBICIDE SELECTIVITY STUDIES ON TWO CONIFEROUS PLANTATION SPECIES IN SOUTH-EAST QUEENSLAND

By A. CONSTANTINI, M. J. LEWTY and C. H. WELLS

SUMMARY

The Queensland Department of Forestry has an on-going research programme which evaluates the potential of herbicides for use in its Araucaria cunninghamii and Pinus caribaea var. hondurensis plantations. In this paper, the standard procedures used to test herbicide toxicity to crop species are presented and discussed, and the results of all herbicide evaluations made to date are summarized.

RESUME

Le Ministère de Foresterie de Queensland a un programme de recherches suivi qui évalue les potentialités de herbicides pour être utilisé dans ses plantations d’Araucaria cunninghamii et Pinus caribaea var. hondurensis. Dans cet article, les procédures normaux utilisées pour analyser la toxicité d’herbicides aux essences commerciaux sont présentées et discutées, et les résultats de toutes les évaluations réalisées jusqu’ici sont résumés.

RESUMEN

El Departamento Forestal de Queensland está llevando a cabo un proyecto de investigación, el cual evalúa el potencial del uso de herbicidas en sus plantaciones de Araucaria cunninghamii y Pinus caribaea var. hondurensis. en este artículo se presentan y discuten los procedimientos normales que se han usado para probar la toxicidad para las especies plantadas, y se resumen los resultados de todas las evaluaciones de los herbicidas que se han hecho hasta la fecha.

Introduction

The Queensland Department of Forestry aims to establish 200,000 ha of softwood plantations by the year 2000 (Queensland Department of Forestry 1984). Of this, 50,000 ha will be the native conifer Araucaria cunninghamii Ait. ex. D. Don (hoop pine), and the remainder will be exotic Pinus species, predominately Pinus caribaea Mor. var. hondurensis Barr. et. Golf (caribbean pine), P. elliottii Engelm var. elliottii (slash pine), and hybrids between the two. By 1987, 44,000 ha of native conifers and 114,000 ha of exotic conifers had been established. New plantings in the year comprised 460 ha of A. cunninghamii and 5,300 ha of Pinus species. Some 1,000 ha were second rotation establishment.

Chemical weed control is an essential component of successful plantation establishment in Queensland. Weed management is required in the first two years to ensure good survival, uniform crop vigour, and early dominance of the site (Ryan 1982 and Lewty 1984a). In 1986, weed control in both native and exotic conifer plantations

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was dependent upon three phenoxy herbicides (2,4-D amine; 2,4-D ester; and 2,4,5-T ester) and five non-phenoxy herbicides: glyphosate, simazine, atrazine, and terbumeton/terbuthylazine (Costantini 1986; Costantini and Frodsham 1987).

To ensure that alternatives to the phenoxy chemicals are tested and that the most efficient herbicides are used in plantation establishment, the Queensland Department of Forestry regularly screens new herbicides for their toxicity to both the crop trees and the weeds prevalent during establishment.

Prior to 1981, herbicides were screened in response to specific management problems. Some were tested in routine forestry operations and others in glasshouse or field experiments. Using procedures similar to those outlined in Australian Department of Primary Industries (1979), early field experiments were designed to simultaneously determine herbicide toxicity to weeds and herbicide selectivity (safety) to the crop. A randomized complete block experimental design incorporating a control treatment which received no weed removal was used. Unfortunately the design did not allow herbicide toxicity and weed control effects on crop development to be separated.

In 1981, a new approach to herbicide testing involving two-stage experimentation was adopted. The first stage involves the on-going, systematic screening of a wide range of herbicides for selectivity to crop species. It generates, and continually updates, a data bank of herbicides with potential for use in management. This paper describes the standard screening methodology and presents some of the rationale for the approach adopted. It also presents the data bank which has been generated to date, and includes information from early experiments which used differing methodologies.

The second stage of herbicide testing is initiated in response to specific weed problems. Screening herbicides for their weed control efficacy both throughout the range of environmental conditions, and for the spectrum of weeds experienced in Queensland would be logistically impossible. When specific weed problems arise, herbicides are selected from the crop toxicity data base and are tested for their usefulness in weed control. For example, Costantini and Podberscek (1987) reported a study where six herbicides were tested for their potential in controlling, *Setaria sphacelata* var. *sericea*, a serious weed encountered in the afforestation of pasture country with *P. caribaea* var. *hondurensis*. Similarly, Lewty and Frodsham (1987) used the data base to select herbicides to be tested in controlling *Cynodon dactylon*, an important weed in the establishment phase of *A. cunninghamii*.

**Standard Procedures for Assessing Crop Herbicide Toxicity**

**Site**

The methodology involves field-based experimentation. Sites with uniform soil types, free of ash heaps and easily accessible from forestry offices are selected. They are located well away from water courses and land boundaries shared with other land users.

**Treatments**

Any number of herbicides or herbicide mixtures (knockdown plus a residual, or grass activity plus a woody weed activity, for example) can be included in the basic experimental design. Six, tested at three application rates, are conventionally used in the Queensland Department of Forestry’s screening programme. For each herbicide the middle rate tested is that recommended by the manufacturer for effective weed control. The lower and higher rates are half and twice the middle rate respectively. [This procedure follows Australian Department of Primary Industries (1979)*].

*If a response surface is required, then additional rates would need to be tested.
The three important possibilities for herbicide applications in plantation establishment include:
- pre-plant;
- post-plant, directed (to avoid the crop);
- post-plant, ‘over-the-top’ (contact is made with the crop).

The basic experimental design can include any, or all, of these. Screening trials in Queensland have generally included only pre-plant and post-plant, over-the-top options.

The consequence of the restricted design is information loss. An assumption can be made that if a post-plant, over-the-top application is non-toxic, then a post-plant, directed application will be non-toxic. The reverse is not true however, and many useful herbicides, such as glyphosate, will also require testing as directed sprays.

Similarly, post-plant, directed applications can not be assumed to have the same response as pre-plant applications which also avoid the crop. For example, hexazinone trialled with outplanted *A. cunninghamii* has not affected transplants when applied two weeks pre-plant at rates less than 3.0 kg ha\(^{-1}\), but has affected transplants when applied post-plant, directed at rates above 1.5 kg ha\(^{-1}\). Experiences with fluazifop-butyl have also been interesting. With *P. caribaea* var. *hondurensis*, it has been safely applied post-plant, both directed and over-the-top, at rates up to 4 kg ha\(^{-1}\). However, rates of 2 kg ha\(^{-1}\) applied pre-plant three days prior to outplanting with open-rooted *P. caribaea* var. *hondurensis* transplants have caused damage when crop roots were compacted with the sprayed top-soil (Costantini, 1986).

**Design and Layout**

A randomized complete block experimental design is used with three replications of ‘n’ plots, where \(n = \left[\text{No. of herbicides} \times 3 \text{ (rates)} + 1 \text{ (control)}\right] \times 2 \text{ (times of application)}\). A six herbicide experiment requires 38 plots per replication. Each plot is a 20 tree, line plot with one metre spacing between seedlings. Adjacent plots are spaced at two metres so that their respective spray edges are well separated. In a six herbicide experiment with three replications, a total area of 0.55 ha is required.

**Establishment**

Physical site preparation involves overall ploughing to a depth of 25 cm followed by Napier mounding along the planting line. Mounds produced are approximately one metre wide, 25 cm high and 0.2m\(^2\) in cross sectional area. If necessary, glyphosphate, a herbicide with known non pre-plant toxicity to both crop species, is used to ensure that all plots are weed free at the time of establishment.

Screening experiments are conducted with newly out-planted seedlings. (In the case of post-plant treatments after transplanting shock has subsided). At this early age, the transplants can be expected to be most sensitive to the routine field application of herbicides (Swarbrick 1984). Genetically improved, tubed nursery stock are used in experimentation to ensure good survival and uniform development. For the post-plant treatments, plots can be refilled prior to application of treatments to ensure 100% survival.

The inclusion of both pre-plant and post-plant application times in an experiment necessitates that either:
- all seedlings are planted at one time, and herbicide applications are split (2-4 days prior to planting for ‘pre-plant’ and 4-6 weeks after planting for ‘post-plant’); or,
- all herbicide applications are made at one time, and planting times are split (2-4 days after spraying for ‘pre-plant’ plots and 4-6 weeks before spraying for ‘post-plant’ plots).
By tradition, the former approach is used for *A. cunninghamii* and the latter for *P. caribaea* var. *hondurensis*.

Both approaches have weaknesses. If the dates of planting are synchronized, then pre-plant sprays will be applied 4-6 weeks before the post-plant sprays. Any differing environmental conditions between the application times can influence herbicide selectivity (Davenhill and Preest, 1976). Conversely if the spraying times are coincident, seedlings in post-plant plots will be 4-6 weeks older than seedlings in pre-plant plots. In this event, seedling development differences between pre-plant and post-plant treatments can not be meaningfully compared. For either approach, there is a need for both weed-free, pre-plant and weed-free, post-plant controls which receive no herbicide application.

Apart from the selection of upper and lower rates, all manufacturer guidelines are followed in preparing mixtures. Where use of a surfactants is suggested, the combined effect of herbicide and surfactant is tested. Treatments are applied with a small, precision instrument, typically an ‘Auto Drencher Injector’ fitted with a solid cone nozzle. The equipment is calibrated so that when the nozzle is held at a fixed height above ground level, a pre-defined volume of solution is delivered uniformly in a one metre diameter spray pattern over the planting spot (or transplants).

The entire experimental area is fenced to exclude cattle and maintained weed free with periodic directed applications of glyphosate (a herbicide with a known non-toxicity to both crop species).

**Measurements**

Assessments made include seedling health and height development at 0, 2, 4 and 9-12 months, and dry shoot biomass formation at 9-12 months, if required. More frequent assessments have been found to contribute little additional useful information. Extending the measurement period may be useful to demonstrate longevity of any herbicide toxicity; but in Queensland, where the objective of the plantation establishment phase is rapid early development, interest lies in early toxicity effects.

The visual rating system for health classes is as follows:

1. Healthy;
2. Some herbicide effect (slight discolouration);
3. Severely affected by herbicide (moderate to major discolouration, or obvious distortions or stunting);
4. Dead from herbicide;
5. Unhealthy from causes other than herbicides;
6. Dead from causes other than herbicides.

Categories 5 and 6 allow factors such as browsing by native animals and storm losses to be excluded from the analyses.

Recent herbicide screening experiences in Queensland’s nurseries have confirmed that dry shoot biomass formation is a more sensitive indicator of herbicide toxicity than height development. In future, biomass determinations will be used to check treatments with non-significant height development differences. Seedlings will be harvested at ground level, accumulated for each plot and fed through a field ‘litter mulcher’ to simplify oven drying and weighing.

**Analyses**

A standard ‘analysis of variance’ statistical package is used to process data entered directly from field forms. The most useful approach is to analyse experiments as randomized complete block designs with (typically) 38 treatments in three blocks. As suggested by Steel and Torrie (1980), survival or visual health class data frequently
requires arcsine square root or square root transformation prior to analysis of variance in order to satisfy the assumption of homoscedasticity. Significant negative and positive deviations from the control are detected by Duncan's multiple range test, and may suggest treatment toxicity and treatment stimulation* respectively. A factorial analysis (herbicide x rate x time - but excluding the control) can also be made if there is a need to compare herbicides or identify interactions.

The choice of health classes to be analysed is optional. Queensland practice is to aggregate classes 1 and 2 for survival calculation. Data for class 2, 3 or 4 occurrences are useful for qualitative descriptions of herbicide toxicity.

The basic experimental design does give a statistically reliable estimate of the true differences between means. Standard errors of means are typically five to seven centimetres for height development at 9-12 months. Heights in untreated controls typically reach 100-120 cm. Confidence limits for survival can be determined from tabulated 'confidence belts for proportions'. In screening experiments, untreated controls usually experience survivals exceeding 90%. With the methodology outlined, the 95% confidence limits for an observed 90% survival are 78%-99% (Steel and Torrie 1980).

**Results from Early and Recent Herbicide Selectivity Studies**

Table 1 details the herbicides investigated to date by the Queensland Department of Forestry. Tables 2 and 3 summarize the data base of herbicide toxicities to *A. cunninghamii* and *P. caribaea* var. *hondurensis*. The data base is compiled from broadscale field experiences, pre-1981 screening trials and recent screening trials which employ the methodology outlined in Part I. Some of the results from the latter have been reported by Lewty (1984b); Costantini (1986); and Costantini and Frodsham (1987). Information about chemical activity and conventions with chemical nomenclature in Table 1 follow manufacturer descriptions, Hodogaya Chemical Company (1978) and Queensland Agricultural College (1983).

The columns headed 'maximum safe dose' in Tables 2 and 3 have the most important information for field foresters. They represent the rates at which herbicides can be safely applied in over-the-top applications. The bases of their determination are conservative. If no toxicity is observed in the range tested, then the upper rate in the range is accepted as a 'maximum' safe dose. If toxicity is observed in the range tested, then half the minimum rate at which toxicity is experienced is entered as the maximum safe dose. [Davenhill and Preeest (1976) adopt a similar approach]. Finally, if the lowest rate tested is toxic, then the maximum safe dose is indicated as being less than that rate.

The selectivity information presented in the 'maximum safe dose' columns of Tables 2 and 3 applies to the particular environmental conditions outlined in Table 4. Tables 2 and 3 are cross-referenced to Table 4 via the 'code' column. The data indicates herbicides which have potential for use in afforestation.

The data base presented in Tables 2 and 3 is updated regularly as new herbicides are evaluated.

**Acknowledgements**

Bruce Hogg, John Simpson, Matt Grant and Marks Nester kindly provided constructive criticism of the manuscript. The work reported in this paper forms part of the silvicultural research programme of the Queensland Department of Forestry.

*An example of treatment stimulation is reported by Sands and Zed (1979) for sub-herbicidal concentrations of atrazine applied to *P. radiata*.**
Table 1

Herbicides tested for their toxicity to *A. cunninghamii* or *P. caribaea* var. *hondurensis* in Queensland.

<table>
<thead>
<tr>
<th>Common name of the active constituent</th>
<th>Commercial formulation g/litre or g/kg*</th>
<th>Susceptible weeds **</th>
<th>Herbicide action ***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acifluorfen</td>
<td>Blazer 224 L.C.</td>
<td>PS</td>
<td>K</td>
</tr>
<tr>
<td>Alloxydim</td>
<td>Fervin 700 S.P.</td>
<td>GA</td>
<td>K</td>
</tr>
<tr>
<td>Ametryn</td>
<td>Primatol 500 S.C.</td>
<td>SGA</td>
<td>RK</td>
</tr>
<tr>
<td>2,4-D Amine</td>
<td>D-500 500 A.C.</td>
<td>PS</td>
<td>K</td>
</tr>
<tr>
<td>Amitrole</td>
<td>Weedazol 250 A.C.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>Atrazine</td>
<td>Nutrazine 500 S.C.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>Benefuralin</td>
<td>Balan 200 E.C.</td>
<td>SA</td>
<td>R</td>
</tr>
<tr>
<td>Bromacil</td>
<td>Hyvar 800 W.P.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>Buthidazole</td>
<td>Ravage 750 W.P.</td>
<td>PSLA</td>
<td>R</td>
</tr>
<tr>
<td>Chlorsulfuron</td>
<td>Glean 750 D.F.</td>
<td>PS</td>
<td>RK</td>
</tr>
<tr>
<td>Chlorothal-dimethyl</td>
<td>Daethal 750 W.P.</td>
<td>SA</td>
<td>R</td>
</tr>
<tr>
<td>Clopyralid</td>
<td>Lontrel 300 A.C.</td>
<td>PS</td>
<td>K</td>
</tr>
<tr>
<td>Dalapon</td>
<td>DPA 740 L.C.</td>
<td>GA</td>
<td>RK</td>
</tr>
<tr>
<td>Dicamba</td>
<td>Banvel 200 A.C.</td>
<td>PS</td>
<td>RK</td>
</tr>
<tr>
<td>Diclofenvil</td>
<td>Casaron 67.5 GR.</td>
<td>GA</td>
<td>RK</td>
</tr>
<tr>
<td>Dichlorprop</td>
<td>Farmco DP 600 E.C.</td>
<td>P</td>
<td>K</td>
</tr>
<tr>
<td>Diphenamid</td>
<td>Enide 500 W.P.</td>
<td>SA</td>
<td>R</td>
</tr>
<tr>
<td>Diuron</td>
<td>Diuron 500 S.P.</td>
<td>SGA</td>
<td>RK</td>
</tr>
<tr>
<td>E.P.T.C.</td>
<td>Eptam 720 E.C.</td>
<td>SA</td>
<td>R</td>
</tr>
<tr>
<td>Ethidimuron</td>
<td>Ustilan 700 W.P.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>2, 4-D ethyl-ester</td>
<td>D-800 800 E.C.</td>
<td>PS</td>
<td>K</td>
</tr>
<tr>
<td>Fenoxaprop-ethyl</td>
<td>Whip 120 E.C.</td>
<td>GA</td>
<td>K</td>
</tr>
<tr>
<td>Flamprop-methyl</td>
<td>Materan 105 E.C.</td>
<td>A</td>
<td>K</td>
</tr>
<tr>
<td>Fluazifop-butyl</td>
<td>Fusilade 212 E.C.</td>
<td>GA</td>
<td>K</td>
</tr>
<tr>
<td>Fluometuron</td>
<td>Cotoran 800 W.P.</td>
<td>SGA</td>
<td>RK</td>
</tr>
<tr>
<td>Fluoroxypry</td>
<td>Starane 300 E.C.</td>
<td>PS</td>
<td>K</td>
</tr>
<tr>
<td>Fosamine</td>
<td>Krenite 480 L.C.</td>
<td>P</td>
<td>K</td>
</tr>
<tr>
<td>Glufosinate</td>
<td>Basta 200 A.C.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>Roundup 360 E.C.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>Haloxyfop-methyl</td>
<td>Verdict 240 E.C.</td>
<td>GA</td>
<td>RK</td>
</tr>
<tr>
<td>Hexazineone</td>
<td>Velpar L 250 L.C.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>Karbutilate</td>
<td>Resdone 800 W.P.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>Linuron</td>
<td>Afalon 500 W.P.</td>
<td>PSA</td>
<td>RK</td>
</tr>
<tr>
<td>Methazole</td>
<td>Probe 800 W.P.</td>
<td>PSA</td>
<td>RK</td>
</tr>
<tr>
<td>Metsulfuron-methyl</td>
<td>Ally 600 D.F.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>Metholachlor</td>
<td>Dual 720 E.C.</td>
<td>A</td>
<td>R</td>
</tr>
<tr>
<td>Oryzalin</td>
<td>surflan 500 L.C.</td>
<td>AS</td>
<td>R</td>
</tr>
<tr>
<td>Oxofluorfen</td>
<td>Goal 240 E.C.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>Paragquat</td>
<td>Gramoxide 200 A.C.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>Pebulate</td>
<td>Tillam 720 E.C.</td>
<td>PSA</td>
<td>R</td>
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<td>Picloram</td>
<td>Tordan 2G 50 G.R.</td>
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<td>K</td>
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<td>Propazine</td>
<td>Gesamil 500 W.P.</td>
<td>SGA</td>
<td>R</td>
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<tr>
<td>Propyzalide</td>
<td>Kerb 50 500 W.P.</td>
<td>A</td>
<td>K</td>
</tr>
<tr>
<td>Quinofolep</td>
<td>Assure 95 E.S.C.</td>
<td>GA</td>
<td>K</td>
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<tr>
<td>Sethoxydim</td>
<td>Sertin 186 S.P.</td>
<td>SGA</td>
<td>K</td>
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<tr>
<td>Simazine</td>
<td>Simazine 500 S.C.</td>
<td>SGA</td>
<td>R</td>
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<tr>
<td>Sulpetometuron-methyl</td>
<td>Oust 750 D.F.</td>
<td>PSLA</td>
<td>RK</td>
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<tr>
<td>T.C.A.</td>
<td>T.C.A. 835 S.P.</td>
<td>GA</td>
<td>R</td>
</tr>
<tr>
<td>Tubethuron</td>
<td>Spike 200 W.P.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>Terbacil</td>
<td>Sinbar 800 W.P.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>Terbumeton</td>
<td>Caragard 500 W.P.</td>
<td>PSLA</td>
<td>RK</td>
</tr>
<tr>
<td>2,4,5-T ester</td>
<td>T-400 400 E.C.</td>
<td>PS</td>
<td>R</td>
</tr>
<tr>
<td>Tetrapion</td>
<td>Frenock 750 A.C.</td>
<td>GA</td>
<td>RK</td>
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<tr>
<td>Thiadiazuron</td>
<td>Erbotan 800 W.P.</td>
<td>GA</td>
<td>RK</td>
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<tr>
<td>Triclopyr</td>
<td>Garlon 480 E.C.</td>
<td>PS</td>
<td>K</td>
</tr>
<tr>
<td>Tridiphen</td>
<td>Tandem 480 E.C.</td>
<td>A</td>
<td>K</td>
</tr>
<tr>
<td>Trifluralin</td>
<td>Tiran 400 E.C.</td>
<td>SA</td>
<td>R</td>
</tr>
</tbody>
</table>

* E.C. = emulsifiable concentrate; GR. = Granular; A.C. = aqueous concentrate; L.C. = Liquid concentrate; S.P. = soluble powder; D.F. = dry flowable; W.P. = wettable powder.

** P = perennial broadleaves  
*** R = residual activity  
S = soft weeds  
G = perennial grass  
K = knockdown activity  
A = annual grass
### Table 2

Herbicide toxicity data bank for *P. caribaea* var. *hondurensis*.

<table>
<thead>
<tr>
<th>Herbicide active constituent (a.c.)</th>
<th>High and low rates tested kg ha a.c.</th>
<th>Code*</th>
<th>Toxicity Effect #</th>
<th>Maximum safe dose kg ha a.c.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acifluorfen</td>
<td>0.1 - 0.4</td>
<td>B</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Alloxydim</td>
<td>0.23 - 0.92</td>
<td>B</td>
<td>y(0.92)</td>
<td>n</td>
</tr>
<tr>
<td>Ametrix</td>
<td>2.3 - 9.1</td>
<td>H</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Amitrole</td>
<td>2.0 - 4.0</td>
<td>F, J</td>
<td>y(4.0) a(4.0) y(4.0)</td>
<td>2.0</td>
</tr>
<tr>
<td>Atrazine</td>
<td>3.0 - 6.0</td>
<td>J</td>
<td>y(3.0)</td>
<td>n</td>
</tr>
<tr>
<td>Benfluralin</td>
<td>0.4 - 1.7</td>
<td>H</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Chlorsulfuron</td>
<td>0.008 - 0.060</td>
<td>B</td>
<td>y(0.015)</td>
<td>y(0.015) y(0.015)</td>
</tr>
<tr>
<td>Chlorothal-dimethyl</td>
<td>10 - 20</td>
<td>F, H</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Clopyralid</td>
<td>0.9 - 3.6</td>
<td>F</td>
<td>y(20) a b b</td>
<td>n</td>
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<td>Dalapon</td>
<td>10 - 20</td>
<td>F</td>
<td>y(20) a b b</td>
<td>n</td>
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<td>Dichlobenil</td>
<td>4.05</td>
<td>F</td>
<td>n</td>
<td>n</td>
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<tr>
<td>Diphenamid</td>
<td>2.8 - 11.4</td>
<td>H</td>
<td>n</td>
<td>n</td>
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<tr>
<td>E. P. T. C.</td>
<td>3.4 - 16.9</td>
<td>H</td>
<td>y(16.9) y(3.4)</td>
<td>n</td>
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<tr>
<td>2, 4-D ethyl-ester</td>
<td>1.0</td>
<td>J</td>
<td>n</td>
<td>y n n</td>
</tr>
<tr>
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<td>0.12 - 0.48</td>
<td>B</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
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<td>B</td>
<td>n</td>
<td>n</td>
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<td>Fluoroxypyr</td>
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<td>n</td>
<td>n</td>
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<td>Fosamine</td>
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<td>y(2.0)</td>
<td>y(2.0)</td>
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<tr>
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<td>y(0.8)</td>
<td>y(0.8)</td>
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<tr>
<td>Haloxypop-methyl</td>
<td>0.25 - 2.0</td>
<td>B</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Hexazinone</td>
<td>1.3 - 4.0</td>
<td>E</td>
<td>y(1.3)</td>
<td>y(1.3) y(2.0) y(4.0)</td>
</tr>
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<td>Linuron</td>
<td>1.7 - 2.2</td>
<td>F</td>
<td>n</td>
<td>n</td>
</tr>
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<td>Methazole</td>
<td>1.2</td>
<td>F</td>
<td>n</td>
<td>n</td>
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<td>Metsulfuron-methyl</td>
<td>0.009 - 0.036</td>
<td>B</td>
<td>y(0.009)</td>
<td>y(0.018)</td>
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<tr>
<td>Oryzalin</td>
<td>1.25 - 5.0</td>
<td>B</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Oxyfluorfen</td>
<td>0.24 - 0.96</td>
<td>B</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Paraquat</td>
<td>5.6</td>
<td>H</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Pelubreline</td>
<td>3.4 - 13.6</td>
<td>H</td>
<td>y(13.6)</td>
<td>y(13.6)</td>
</tr>
<tr>
<td>Picloram</td>
<td>2.2</td>
<td>F</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Propazine</td>
<td>1.0 - 4.0</td>
<td>F, H</td>
<td>y(2.0)</td>
<td>y(1.0)</td>
</tr>
<tr>
<td>Propyzamide</td>
<td>2.5 - 5.0</td>
<td>F</td>
<td>n</td>
<td>b</td>
</tr>
<tr>
<td>Quialofop</td>
<td>0.024 - 0.096</td>
<td>B</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Sethoxdym</td>
<td>0.4 - 1.5</td>
<td>B</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Simazine</td>
<td>3 - 12</td>
<td>J, B</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Sulfometuron-methyl</td>
<td>0.186 - 0.75</td>
<td>B</td>
<td>n</td>
<td>n</td>
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<tr>
<td>T.C.A.</td>
<td>17 - 180</td>
<td>H</td>
<td>y(34.9)</td>
<td>y(34.9) y(90) y(90)</td>
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<tr>
<td>Tebuthiuron</td>
<td>1.1 - 4.4</td>
<td>B</td>
<td>y(1.1)</td>
<td>y(1.1)</td>
</tr>
<tr>
<td>Terbacil</td>
<td>6 - 12</td>
<td>H</td>
<td>y(6)</td>
<td>y(6) y(6) y(6)</td>
</tr>
<tr>
<td>Terbumeton</td>
<td>5 - 20</td>
<td>F, B</td>
<td>y(10)</td>
<td>y(10) b y(10)</td>
</tr>
<tr>
<td>2,4,5-T ester</td>
<td>1.0</td>
<td>J</td>
<td>n</td>
<td>y n n</td>
</tr>
<tr>
<td>Tetraclon</td>
<td>6 - 12</td>
<td>F</td>
<td>a(12)</td>
<td>y(6) a(12) a(12)</td>
</tr>
<tr>
<td>Triclopyr</td>
<td>0.48 - 1.92</td>
<td>B</td>
<td>y(1.92)</td>
<td>y(0.48) n n n n</td>
</tr>
<tr>
<td>Tridiphene</td>
<td>0.48 - 1.92</td>
<td>B</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Trifluralin</td>
<td>0.7 - 2.8</td>
<td>H</td>
<td>n</td>
<td>n</td>
</tr>
</tbody>
</table>

* = code for accessing Table 4, details of experimentation.

# = y = toxicity effect observed; n = no toxicity effect observed;
  a = limitations in experimental design, toxicity expected;
  b = limitations in experimental design, toxicity not expected;
() = lowest rate at which toxicity was observed or expected.
### Table 3
Herbicide toxicity data bank for *A. cunninghamii*.

<table>
<thead>
<tr>
<th>Herbicide active constituent (a.c.)</th>
<th>High and low rates tested kg/ha a.c.</th>
<th>Code*</th>
<th>Toxicity Effect # Over the top Survival Development</th>
<th>Pre Plant Survival Development</th>
<th>Maximum safe dose kg/ha a.c.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acifluorfen</td>
<td>0.22 0.90</td>
<td>A n n n n n</td>
<td></td>
<td></td>
<td>0.90</td>
</tr>
<tr>
<td>Alloxydim</td>
<td>0.5 2.1</td>
<td>A n n n n n</td>
<td></td>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td>Ametryn</td>
<td>4.0 8.0</td>
<td>D n n n n n</td>
<td></td>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td>2,4-D amine</td>
<td>0.350</td>
<td>I n n n n n</td>
<td></td>
<td></td>
<td>0.350</td>
</tr>
<tr>
<td>Amitrole</td>
<td>2.5 5.0</td>
<td>D, J n a n n n</td>
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<td></td>
<td>&lt;2.5</td>
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<tr>
<td>Atrazine</td>
<td>1.0 4.0</td>
<td>D n n n n n</td>
<td></td>
<td></td>
<td>4.0</td>
</tr>
<tr>
<td>Benefuralin</td>
<td>0.4 1.7</td>
<td>I n n n n n</td>
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<td></td>
<td>1.7</td>
</tr>
<tr>
<td>Bromacil</td>
<td>0.38 1.50</td>
<td>D n y(0.38) n y(1.5)</td>
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<td>0.5 2.0</td>
<td>A y(0.5) y(1.0)</td>
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<td>&lt;0.5</td>
</tr>
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<td>Chlorsulfuron</td>
<td>0.08 0.30</td>
<td>A n y(0.15) n n</td>
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<td>0.08</td>
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<tr>
<td>Chlorothal-dimethyl</td>
<td>5.7 22.7</td>
<td>I n n n n n</td>
<td></td>
<td></td>
<td>22.7</td>
</tr>
<tr>
<td>Clopyralid</td>
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<td>A n n n n n</td>
<td></td>
<td></td>
<td>3.6</td>
</tr>
<tr>
<td>Dalapon</td>
<td>5.8 22.4</td>
<td>J n n n n n</td>
<td></td>
<td></td>
<td>22.4</td>
</tr>
<tr>
<td>Dicamba</td>
<td>0.25 3.0</td>
<td>A y(3.0) y(1.0) n</td>
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<td>0.5</td>
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<td>Dichlorprop</td>
<td>0.9 3.6</td>
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<td>Diphenamid</td>
<td>2.8 10.9</td>
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<td>E.P.T.C.</td>
<td>4.3 16.9</td>
<td>I y(16.9) y(8.4)</td>
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<td>Ethidimuron</td>
<td>1.0 2.0</td>
<td>D n n n n n</td>
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<td>0.4</td>
<td>J n n n n n</td>
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</tr>
<tr>
<td>Fenoxaprop-ethyl</td>
<td>0.12 0.48</td>
<td>A n n n n n</td>
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<td></td>
<td>0.48</td>
</tr>
<tr>
<td>Flamprop-methyl</td>
<td>0.2 0.8</td>
<td>A n y(0.2) n y(0.4)</td>
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<td>&lt;0.2</td>
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<tr>
<td>Fluazifop-butyll</td>
<td>1.0 4.0</td>
<td>A, C n y(2.0) n n</td>
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<td>1.0</td>
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<td>Flumeturon</td>
<td>2.3 6.8</td>
<td>I y(2.3) y(2.3)</td>
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<td>Glufosinate</td>
<td>0.6 2.4</td>
<td>A y(0.6) y(0.6) n</td>
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</tr>
<tr>
<td>Glyphosate</td>
<td>3.2 6.4</td>
<td>D y(3.2) y(3.2) n n</td>
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<td>&lt;3.2</td>
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<tr>
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<td>0.24 2.96</td>
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<td>0.96</td>
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<td>0.8</td>
</tr>
<tr>
<td>Karbutilate</td>
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<td>Metholachlor</td>
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<td>5.8</td>
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<tr>
<td>Oxyfluorfen</td>
<td>0.3 1.9</td>
<td>A, C n n n n n</td>
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<td></td>
<td>1.9</td>
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<tr>
<td>Parquat</td>
<td>0.6 1.1</td>
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<td>1.1</td>
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<td>Peflurate</td>
<td>3.4 13.6</td>
<td>I n n y(13.6)</td>
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<tr>
<td>Picloram</td>
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<td>Propazine</td>
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<td>1.1</td>
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<td>Quinclorop</td>
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<td>Sethoxydim</td>
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<td>Simazine</td>
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<td>A y(0.38) y(0.19) y(0.75)</td>
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<td>T.C.A.</td>
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<td>I a a y(68) a</td>
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<td>2.2 9.0</td>
<td>I y(2.2) y(2.2)</td>
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<td></td>
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<tr>
<td>Terbumeton</td>
<td>2.0 10.0</td>
<td>D n n n n n</td>
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<td>10.0</td>
</tr>
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<td>Tetrapion</td>
<td>2.5 5.0</td>
<td>D y(5.0) y(2.5) n</td>
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<td>&lt;2.5</td>
</tr>
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<td>Thiazafluron</td>
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<td>2.0</td>
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<tr>
<td>Triclopyr</td>
<td>0.5 4.0</td>
<td>A n y(1.0) n n</td>
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<td>0.5</td>
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<tr>
<td>Tridiphane</td>
<td>0.5 1.9</td>
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<td>1.9</td>
</tr>
<tr>
<td>Trifluralin</td>
<td>0.7 2.8</td>
<td>I n n n n n</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* code for accessing Table 4, details of experimentation.

# y = toxicity effect observed; n = no toxicity effect observed; a = limitations in experimental design, toxicity expected; b = limitations in experimental design, toxicity not expected; () = lowest rate at which toxicity was observed.
Table 4

Experimentation details for data presented in Tables 2 and 3.

<table>
<thead>
<tr>
<th>Code^{a}</th>
<th>Location^{b}</th>
<th>Classification^{c}</th>
<th>Sand %</th>
<th>Silt %</th>
<th>Clay %</th>
<th>Texture^{e}</th>
<th>Organic carbon %^{f}</th>
<th>pH</th>
<th>Test Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Yarraman</td>
<td>lateritic Krasnozem</td>
<td>55</td>
<td>20</td>
<td>25</td>
<td>Clay loam</td>
<td>5.3</td>
<td>6.5</td>
<td>Newly planted <em>A. cunninghamii</em></td>
</tr>
<tr>
<td>B</td>
<td>Toolara</td>
<td>lateritic podzolic</td>
<td>83</td>
<td>11</td>
<td>6</td>
<td>Loamy sand</td>
<td>1.6</td>
<td>4.5</td>
<td>Newly planted <em>P. caribaea var. hondurensis</em></td>
</tr>
<tr>
<td>C</td>
<td>Yarraman</td>
<td>lateritic krasnozem</td>
<td>55</td>
<td>20</td>
<td>25</td>
<td>Clay loam</td>
<td>5.3</td>
<td>6.5</td>
<td>21 months old <em>A. cunninghamii</em></td>
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<tr>
<td>D</td>
<td>Imbil</td>
<td>brown earth</td>
<td>41</td>
<td>24</td>
<td>35</td>
<td>Clay loam</td>
<td>2.4</td>
<td>6.7</td>
<td>Newly planted <em>A. cunninghamii</em></td>
</tr>
<tr>
<td>E</td>
<td>Toolara</td>
<td>lateritic podzolic</td>
<td>80</td>
<td>8</td>
<td>12</td>
<td>Sandy loam</td>
<td>0.6</td>
<td>5.6</td>
<td>5 month old <em>P. caribaea var. hondurensis</em></td>
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<tr>
<td>F</td>
<td>Beerwah</td>
<td>lateritic podzolic</td>
<td>83</td>
<td>7</td>
<td>10</td>
<td>Sandy loam</td>
<td>1.3</td>
<td>5.1</td>
<td>Newly planted <em>P. caribaea var. hondurensis</em></td>
</tr>
<tr>
<td>H</td>
<td>Beerwah</td>
<td>lateritic podzolic</td>
<td>85</td>
<td>10</td>
<td>5</td>
<td>Loamy sand</td>
<td>2.9</td>
<td>5.5</td>
<td><em>P. caribaea var. hondurensis</em> pot trials</td>
</tr>
<tr>
<td>I</td>
<td>Imbil</td>
<td>krasnozem</td>
<td>44</td>
<td>19</td>
<td>37</td>
<td>Clay loam</td>
<td>1.6</td>
<td>5.9</td>
<td><em>A. cunninghamii</em> pot trials</td>
</tr>
<tr>
<td>J</td>
<td>EXTENSIVE FIELD TRIALS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*A. cunninghamii &amp; <em>P. caribaea var. hondurensis</em></td>
</tr>
</tbody>
</table>

* a accessed from Tables 2 & 3.
* b locations are 26.27'S and 152.153'E.
* c follows Stace *et. al.* (1968).
* d top 10 cm of the soil sampled.
* e based on international fractions.
* f methodology follows Lambert (1976).
REFERENCES


Given the current interest in world deforestation, present ecological disasters and the concern over the longterm future of the tropical forest, publication of this book is opportune. The book includes essays by eminent historians, geographers, economists and foresters. They have drawn upon archival material and national and trade statistics for their documentation, description and analysis of the continuing process of deforestation. It is edited by two historians who have written the preface and introduction which gives the global picture. It is a companion volume to their earlier book “Global Deforestation and the Nineteenth-Century World Economy”.

The studies are grouped into three parts:


Part 2. Linkages-The Global Timber Trade (2 essays on the Global Timber Trade and on the North America-Japanese Timber Trade); and

Part 3. Forests of the Developed World (three essays on Tasmanian Forestry, forestry in the United States of America and in the USSR).

The studies show that the process of deforestation in the Developing World has a number of causes. One of the principal ones is population increase and the accompanying need for an expanded agricultural base and higher demands on fuel and other resources. At the same time, forests have been regarded as valuable national capital resources which wealthy developed nations have been eager to acquire or use to meet their own needs for forest and other products. Forest exploitation has also been a contributory factor to the overall deforestation. In the cases of Brazil and Thailand, logging triggered off the deforestation but the destruction and waste arising from land clearance and settlement in these countries has been infinitely greater. Development of areas for cash crops and the demand for cash and migrant labour by colonial and other governments are blamed in part for the deforestation in West Africa and in Assam. Politics played a significant part in defeating the efforts of the Indian Forest Service to protect the forests of Kumaon. The effects of deforestation are becoming all too evident in some of these countries. Flooding and landslides are now more common in the wetter parts of the tropics affected by deforestation whilst desertification is expanding in the drier parts.

To some extent the picture is less gloomy in the Developed World where there have been significant efforts to reforest or regenerate forests in hitherto over-exploited areas. In the USA, considerable areas of land previously cleared for agriculture have reverted for economic reasons to forest. Implementation of fire control measures has allowed many areas to regenerate so that the annual increment exceeds the current rate of cut. However, the author in the essay on deforestation in the USSR is somewhat less sanguine that the previous overcutting there has been reversed. The forests in western Russia and the Baltic states were also seriously damaged during World War II and this contributed to the need to exploit forests beyong the Urals.

This book will be of particular interest to foresters working in the countries which are
the subject to the various essays. It will also have a much wider appeal to readers interested in the world wide problem of deforestation. It does not pretend to predict or prescribe what is to be done to meet the problem but it does show how global trends develop and the broad range of issues involved. The analyses given in the essays should go some way to rectify the views on the causes of deforestation so stridently proclaimed by some sections of the ‘ecological’ lobby. The editors make the point that whereas the Developed World was previously able to tap the resources on other continents, Developing countries face a profoundly different and more difficult prospect. Exploitable forest hinterlands are limited whilst population is increasing. Financial and other assistance will be necessary if new forests are to be developed and forest management intensified.

It is unfortunate that the price of this book is high. A wider readership might be ensured if the book could be reissued in a paperback edition.

P. W. T. Henry

Commonw. For. Rev. 67(4), 1988


This small paperback is a review of the use of genetic resources, mainly for the improvement of already domesticated plant and animal species, for food and raw materials. Some basic terms used throughout the book are defined in the opening chapter. Chapter 2 surveys those crop groups which have been improved and describes the value of the improvements in terms of increased yield, pest resistance and other desirable traits. The crop groups covered are: cereals, root crops, oil crops, vegetables and pulses, sugar crops, commodity crops, timber, forage crops, livestock (including insects) and aquaculture. Data of world average production (1978–80) and the percentage contribution of each crop towards group production is included.

Further chapters indicate that the increasing use of the wild genetic resources is mainly in the major world agricultural crops and that improvements are primarily for disease resistance. Some examples of rarer benefits of wild genes are included such as the introduction of brown trout strains with increased tolerance to river water acidity caused by acid rain in Norway.

Problems in the use of wild genetic resources, the international inequalities in their distribution and use and the problems of private ownership of cultivars and varieties are discussed. Potential uses of wild genetic resources are envisaged as the culture of biochemicals, the development of new domesticates and the improvement of existing domesticates. Finally, the threats to wild genetic resources and a review of the intricacies of ex situ and in situ conservation are discussed. The authors point out that the majority of conservation strategies are concerned more with ecosystem and species than with the overall gene pool.

Sections of the book which are of particular significance to foresters are brief and principally concerned with the use of trees for timber. With the exception of one or two passing references to the production of biochemicals (eg. latexes, essential oils, medicinals and others chemical feedstocks) no mention is made of non-timber use. The lengthy processes involved in the incorporation of wild genetic resources by tree breeding are noted with the comment that “Foresters are patient people . . .”

Although the contents page helps, the reader is hampered by a poor index which contains only author/organisation and country. The book would benefit from a species
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and subject index. In place of the executive summary at the front of the book, short summaries at the end of each chapter would be more digestable. This publication is the second edition of a 1983 original and suffers from lack of thorough editing. In an otherwise good reference collection only two out of the 193 references were post-1983. A prediction of the distribution of gene banks by 1985 is presumably an un-edited relic from the first edition. Reference is made to provenances of *Pinus oocarpa* from Belize and Nicaragua which since 1985 have been widely recognised as *P. patula* ssp. *tecunumanii*. However, this is a very affordable little review book which is a mine of information and references which should be of particular use to the undergraduate reader.

L. A. Lockhart

Commonw. For. Rev. 67(4), 1988

**Flora of Tropical East Africa.** Edited by R. M. Polhill. Published by A. A. Balkema, Rotterdam/Boston on behalf of the East African Governments.


All of these eleven families which have been recently published, except Hydrostachyaceae and Burmanniaceae, contain some woody plants, either large forest trees, shrubs or lianes. Most are represented by few taxa in E. Africa except the Rubiaceae and Euphorbiaceae, but the smaller Anacardiaceae, Palmae, and Violaceae deserve special mention in this review. Surprisingly, the palms, possibly the family of greatest economic importance to Man is not well represented in Africa or indeed in E. Africa. In fact it is very sparse in the region of this Flora with only twelve indigenous species. Nevertheless some of them form conspicuous elements in certain vegetation types (e.g. *Borassus aethiopum*, *Hyphaene spp*). The Violaceae which is known in Europe to consist exclusively of herbaceous plants such as violets and pansies is represented in the tropics by the large woody genus *Rinorea*, whose species form understorey trees attaining 20 m in height in tropical moist forests. The Anacardiaceae is another family which is well represented in the lower and middle strata of the indigenous forest with no economically important timber trees, but which contains economically important species such as *Anacardium occidentale* ‘Cashew nut’ and *Mangifera indica*, ‘Mango’ as introductions from a past age, plus notable ornamentals such as *Schinus molle* and *Spondias mombin*.

Both the accounts of the families Rubiaceae and Euphorbiaceae are continuations of parts already published. These are mammoth undertakings and the authors of each have devoted most of their professional working lives to their study. The Rubiaceae is a truly enormous and diverse family and richly represented in the East African Flora by some 100 genera and 600 species. In this particular volume the first part of the subfamily Rubioideae is covered. Many of the species again form small trees or shrubs, but *Nauclea* and *Burttidavya* provide beautiful timbers. There are so many genera and species which resemble each other, even though they are not closely related, that it is almost impossible to make a useable key which does not involve looking at small difficult characters. Thus
separate keys to both the Tribes and Genera (herbaceous, pyrophytic, climbing and woody) are provided as a means of identification. We must now anxiously await publication of Part 3, which will complete the treatment of the family.

Volume 2 of Euphorbiaceae is comprised of the Tribe Euphorbieae, with 160 species alone in the genus *Euphorbia*. Half of this number has the succulent 'Candelabra' habit, frequenting the drier parts of the Flora area as conspicuous elements in the landscape. Their taxonomy is notoriously difficult. The remaining species are mostly herbs.

Systematic botanists, especially those involved in floristic work, are often criticized even harangued, particularly by foresters, for the long time they take to complete flora accounts. One has only to look at the enormity of their task as exemplified by these latter two family accounts to appreciate such naivety. Taxonomy, mercifully, cannot and must not be done by halves!

B. T. Styles

*Commonw. For. Rev.* 67(4), 1988

**Trees of the Sahel** Published by GTZ in West Germany.

This book is a 'must' for the prospective forester, silviculturist or interested amateur going to work in Central or West Africa. The good quality colour photographs take the mystery from all the Latin names and dispense with the long process of cross-identification with vernacular names. The vernacular charts are still included and are comprehensively listed. There are well in excess of 100 species classified under headings ranging from management and productivity to uses and propagation. It is exciting to see the emphasis on "the wealth, variety and multiple use potential of the indigenous trees and shrubs of the Sahel".

The response to the book from workers in Nigeria has been positive and immediate. If this publication could be widely available in West Africa it would go far to raise the level of awareness of this dwindling but invaluable resource.

B. Drew

*Commonw. For. Rev.* 67(4), 1988


The simple title and colourful cover of this 'quality' paperback should not mislead the reader. Australia has been involved in forestry in Nepal since before 1966, and the projects that they have funded have many successes to their credit. But although there were occasional problems of staff discontinuity the staff who worked in the Nepal-Australia Forestry Project (NAFP) were professional, realistic, and above all flexible in their approach to and management of rural development forestry in their project area. Dr Griffin, Professor of Forestry and Head of Department at the Australian National University at Canberra has written a detailed personal account of the developments over two decades, and it makes most valuable and interesting reading.

In the early years, the requests for Australian assistance were, understandably, for help with *Eucalyptus* fuel plantations. Most of these were intended to supply the needs of the capital, Kathmandu, and the project achieved some success in developing suitable silvicultural methods, though the scope now for such plantations is very limited. By the end of 1987, however, the project had achieved the impressive record of over 9,000
hectares of plantations of many different species established. But a greater achievement
was the evolution of a successful approach to rural development forestry, which started
with traditional top-down planning and progressed to a sensitive and effective
involvement of people in both the planning and operational aspects of community
forestry work.

The book's value goes wider than forestry in Nepal, though the impressive list of 281
references and the use of a systems modelling approach to project development and
analysis is valuable in itself as a guide to Nepali forestry. Many of the lessons pointed out
can be applied anywhere, and the book is a solid contribution to the literature, and a
guide to practice for project managers. There are twenty-four beautiful colour plates
illustrating the middle hills of Nepal, each of which tells a story, and the text is well laid
out and very readable. An index would have been useful, but even without one it is not
difficult to find information in the text. I would strongly recommend the book to all
concerned with rural development forestry; it records much effort and success by Nepali
and Australian foresters.

P. J. Wood

Commonw. For. Rev. 67(4), 1988

Forestry for Development in Tanzania by Ahlback, A. J. (1988), Arbetsrapport 71,
International Rural Development Centre, Swedish University of Agricultural Sciences,
Uppsala. 150p.

This very thorough report was carried out between 1982 and 1986 as a forestry sector
review on behalf of SIDA, the Swedish International Development Authority.

The first part of the book is a very readable summary of the country, its geography,
people, politics and developmental potential. It incorporates a detailed consideration of
forestry under the headings of natural forests, village forestry, industrial plantation
forestry and forest industries. Then follows a five page section discussing the causes of
deforestation, soil erosion and desertification. All of this is a factual and non-
controversial source of important information.

The most important part of the book is a long section on afforestation, its
achievement, needs and approach. In this a detailed examination of the fuelwood and
other needs of rural areas is presented, with some assessment of how these needs can be
met in a practical way. The 'traditional' forestry approach to village afforestation in the
national interest is well discussed, and also the delicate balance that must be maintained
between coercion and encouragement in rural development forestry. The author's
conclusions are that much more emphasis should be given to forestry extension, and to
the links of forestry with agriculture, both of which ideas are gaining ground rapidly in
other African countries. The incorporation of these subjects into national training
programmes seems to be a slower process than the acceptance of the ideas, however.
Whether a 'massive research programme' is needed as a prerequisite for rural
development forestry remains to be discussed. This reviewer feels that a better
packaging and distribution of existing knowledge should be the first stage in improving
tree conservation and planting in the rural sector. The book contains some useful maps
and tables, and a comprehensive bibliography, and will be a valuable basic reference for
a long time to come.

P. J. Wood

This slim volume in the Tropical Agriculturist series is a simple but comprehensive manual on farming systems and techniques appropriate for the culture of plantains (*Musa acuminata x M. balbisiana AAB*). There are useful sections and photographs for the recognition of disease and nutrient deficiencies. It is intended mainly for West and Central African countries, although it includes a classification of the 60 odd varieties in three main groupings which are grown throughout the wet tropics. Plantains provide one of the cheapest source of starch and it is estimated that over 20 million tonnes are grown annually, mostly for local consumption.

The manual will be of considerable interest and value as a source of technical advice to foresters who are involved in agro-forestry in the wet tropics. Although plantain has been used in the taungya system in West Africa for many years, the manual only records its use as a nurse and food crop in the establishment of coffee and of cacao. The loss of fertility arising from burning during forest clearing is mentioned. Again the advantage of not burning and the increased vigour of the tree and plantain crop has been demonstrated to foresters in the work at Subri in Ghana.

P. W. T. Henry

Commonw. For. Rev. 67(4), 1988


This manual reviews the conditions affecting the quality of cereals and leguminous seed under storage; also, the very large losses which may occur through inadequate drying before storage, poor storage conditions and through rodent and insect pests. Suggestions are made for the improvement at low cost of traditional storage methods; also for new systems of storage at farm level and for larger scale storage by traders, cooperatives and government agencies. There are useful sections on control measures against rodent and insect pests and on store hygiene.

Although marginal to general forestry, the manual is of value to the agro-forester, particularly at field level in areas where expertise on storage may be non-existent. Very considerable tonnages of food are lost during storage and implementation of the measures suggested in this book could reduce this wastage considerably.

P. W. T. Henry

Commonw. For. Rev. 67(4), 1988


This review of the work undertaken in the field of forestry and forest industries by GTZ (as part of the Technical Cooperation programme of the German Federal Republic with
developing countries) is an update to 1985 of the earlier reviews of 1977 and 1980. The German text is accompanied by an English translation.

47 projects undertaken in cooperation with the governments of 36 countries and 6 regional programmes are described. Some projects are multi-donor but most are bilateral. Roughly 40% of the GTZ forestry staff are on leave of absence from the government forest administrations of the Federal States. The projects and programmes cover a wide spectrum of forestry activity within the three basic programmes of:-

- Forest production and forest protection
- The establishment and development of forestry institutions
- Forest industries and wood processing

Given the extent of forest destruction (11-12m ha/a) in the Third World, it is pleasing to see the importance which the German Federal Government places on the forestry and land use sector (the funds supplied from German aid recorded in this review total DM 453 million). The need for local awareness and participation in programmes is emphasised, as is the long term nature of programmes, if these are to be successful. A 6 year minimum time for projects is recognised as desirable and many of the projects are of longer duration. Given the need for continuity, institution building and training at management, technical and worker levels forms a very considerable component of the programme. Systematic and sustained management of existing resources is emphasised, whilst afforestation, reforestation and agro-forestry figure in 40% of the projects. The GTZ are to be congratulated on their achievements to date.

P. W. T. Henry

Commonw. For. Rev. 67(4), 1988


This is a captivating book by two anthropologists. The intriguing and appropriate title represents the Bastar 'tribals' description of the time of transition between day and night. It discusses the failure of a major forestry project in India's largest remaining forest in the district of Bastar, Madhya Pradesh. This project was financed by a World Bank I.D.A. loan and the Indian Government. It was initiated in 1975 after numerous studies by local and foreign consultants between 1964 and 1975. It planned to change a large area of natural tropical forest to a plantation of the exotic pine, Pinus caribaea. The objective was to provide raw material for a long-fibre pulp and paper mill. This was to reduce the need for the large scale importation of wood pulp and newsprint involving precious foreign exchange, and thereby contribute to averting a serious balance of payment deficit.

Unfortunately little attention was paid apparently to the views of the large number of tribals whose whole culture and livelihood was dependent upon the forest in which originally they had acknowledged rights to forest produce. These rights became restricted to privileges and, by 1963, slowly eroded to concessions. A wide communication gap developed between both the Central and State Government Services and the tribal dwellers. The authors write: "In Bastar their role was expected to be menial and marginal, but their compliance with the project was more or less presumed". They explain that this presumption was in error for several reasons, some historical, others the loss of rights: "They (the tribal dwellers) believed the project would not become part of their future; their indifference turned to opposition". As a result the
pine plantation component was terminated in 1981, though a scaled-down version of the pulp and paper mill, based on local bamboo instead of pine, was developed.

The authors go on to state that “governments and international agencies have shown readiness to face the need for community forests when they have been dealing with the problem of tropical forestry. India has been no less alert to this, and social forestry plans have been made in almost every state. But in the midst of this optimism, careful analysis has pointed to the shortcomings of such plans, because most land for social forestry has, to date, been uncultivable”. They also state that “The Indian Government finds itself in the contradictory position of responding in practice to the demands and vicissitudes of international economics by the sacrifice of local interests to the national interest (via a form of internal colonialism), while ideologically proclaiming the aims of social justice and protective tribal development. At the centre of the contradiction lies the seemingly irresistible impulse to develop (read ‘expropriate’) tribal’s resources at the expense of tribal people. The greater the potential yield from this impulse, the greater the rhetoric”. How often this is heard, especially in respect of development in Latin America.

The contents of this book provide a powerful reminder to all foresters and especially forestry planners of some of the problems and difficulties of development, and particularly, the social problems. A solution is not easy though a clear understanding and considered acceptance of these social problems is essential. To quote the authors again: “How then are tribals to communicate with others and be communicated with? What can be said to them? How should their interests be heard? Clearly the answers lie with forests: if ‘tribals’ do gain control of and have uninterrupted responsibility for forests, they will begin to take other steps to adapt to modern forestry rather than simply to reject it. They have a deep and ancient knowledge of trees, and they can learn everything modern science can teach them”. Is the latter over-optimistic in the context of a reasonable time-scale?

The theme of the Eighth World Forestry Congress held in Jakarta, Indonesia in 1979; “Forests for people”, in all its connotations, including educational, environmental and training considerations, is a pointer. It had the aim of examining how forests might best serve people individually and collectively and this includes forest dwellers. Lessons have been learnt. Changes in the approach to development have undoubtedly been and are being made. However, are we moving fast enough in this direction? The belated publication of this book is a timely reminder of the importance of that theme and the need for comprehensive sustained action.

J. W-S
RESEARCH NOTES

Commonw. For. Rev. 67(4), 1988

Fuel and Pole Yields of Coppiced *Eucalyptus saligna* by S. Y. S. Kaumi, Silviculturalist, Forestry Research Department, Kenya Agricultural Research Institute, P.O. Box 57811, Nairobi.

Summary

The paper describes a *Eucalyptus saligna* Sm. coppice thinning experiment which compared fuelwood production and pole sizes when coppice shoots were reduced to varying numbers of stems per stump.

Combined results of two coppice rotations show that any reduction of the number of stems reduces fuelwood volumes, that the size of poles increases with decreasing number of stems per stump and that reducing the stems to various numbers does not significantly affect stump survival.

Introduction

In coppice fuelwood rotations of *Eucalyptus saligna* Sm., the common practice in Kenya, as in other countries in East Africa, is to reduce the number of coppice stems to not more than four per stump at about 18 months after felling. The aim of this operation is to remove stems from the crop which, if left in, would become suppressed and yield poles of too small a diameter to be sold as fuel billets.

Howland, (1969) reported on an experiment laid out in 1960 at Muguga Kenya, to test the effect of ‘singling’ to 1, 2 and 3 stems per stump. His results showed, where diameter of billets is important and the withies from the ‘singling’ could be sold easily, the practice is to be recommended. He recommended leaving three stems per stump, but the effect of the density of stems on pole size was most marked in the two and one stem treatments.

Another experiment, similar to the 1960 plot, was laid out in 1966 with the same objective, that is to compare fuelwood yield and sizes of poles in the first and second coppice rotations, from coppice regrowth reduced to varying numbers of selected stems per stump. This experiment is described in this paper.

The Experimental Site

The experiment was laid out on the former East African Agriculture and Forestry Research Organization’s estate (now the Kenya Agricultural Research Institute) at Muguga, Kenya, latitude 18139S and longitude 368389E, altitude 2070m. The climate is equatorial but, because of the altitude, essentially temperate with a mean monthly maximum temperature of 20.98C and a mean monthly minimum of 10.88C. Mean annual rainfall over 33 years is 970 mm, distributed bimodally, but annual totals are erratic and have varied between 572 mm and 1516 mm.

The soil is a fertile, deep dark red loam derived from volcanic trachyte of quaternary age. The site originally carried a montane semi-deciduous forest which was cleared and the site planted with *Eucalyptus* species in 1915. These plantations were clear-felled and the site re-planted with *E. saligna* in 1959.
Experimental Material, Methods and Design

The experiment was laid out in a three month old *E. saligna* coppice of a crop planted in 1959 at 2.74m x 2.74m (99 x 99) and harvested in 1966. The plot lay-out consisted of a 4 x 4 Latin Square of sixteen 0.019 hectare treatment plots, each with 5 by 5 rows. Four randomised treatments were applied: A, control with no stem reduction and B, C and D in which stems were reduced to three, two and one “best” stem per stump respectively. These treatments were applied 18 months after clear-felling the seedling crop in the first rotation, and the coppice crop in the second rotation. The first and second coppice rotations were felled six years and nine and a half years respectively after clear-felling of the previous crop.

Assessment

At the end of both rotations the following information was collected: number of live stumps, number of shoots per stump above and below 5 cm mid-length diameter (poles and withies respectively) This included all seedling regeneration; the length of poles to 5 cm in diameter, and the mid-length diameter of the poles over bark.

After measurement, the poles were converted into 1m long billets up to 5 cm top diameter and piled into 1 x 1.5 x 2m stacks for assessment of stacked volume. The small pieces under 5cm diameter were counted together with the withies.

Results

Tables I and II show growth data from the first and second coppice rotations.

Discussion

In both rotations the tables show that the different thinning treatments did not significantly affect stump survival. The difference between the highest and lowest number of live stumps among the treatments in the first coppice rotation was 8% and in the second rotation only 6%. Similarly the proportion of stumps in the different treatments which died during the coppice rotations were insignificant.

There was a large difference in the total number of poles between treatments A and D, in both rotations, and a comparatively small difference between treatments B and C. The presence of 47 seedling stems in treatment A in the first coppice rotation and 68 in the second show that denser stocking than any used here can be carried on this site. In the second coppice rotation there were many more poles of mid-length diameter greater than 5 cm and a drop in the numbers of small wood poles compared with those in the first rotation. This change may be accounted for by the longer period of the second rotation than the first one, but also by the presence of seedlings which grew into pole size stems. The decrease in total number of poles less than 5cm mid-length diameter plus withies, in the second coppice rotation, is attributed to a drop in the number of live stumps.

As far as size of poles is concerned, there was a significant increase in diameters and heights in both rotations with decreasing number of stems left per stump. In fuelwood production the preference is for billets that are 10 cm diameter and over. So, if pole size is important, as in fuelwood production, the stands should be thinned to one stem per stump, as this produces the largest poles. It is noted that only in the second coppice rotation was there a significant diameter difference between thinning to two and three stems per stump.

Solid and stacked fuelwood volumes showed a downward trend with reduced numbers of stems. In the first coppice rotation treatment A gave 40% more solid volume, and 43% more stacked volume than treatment D. Second coppice rotation
Table 1
Summary of first Coppice Rotation
Survival and production of *Eucalyptus saligna*
Coppice aged six years, Muguga, Kenya (Measured 1972)

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>Units</th>
<th>TREATMENT</th>
<th>L.S.D. (p=0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Live stumps</td>
<td>Per cent</td>
<td>71</td>
<td>68</td>
</tr>
<tr>
<td>Proportion of stumps died during coppice rotation</td>
<td>Per cent</td>
<td>14.5</td>
<td>21.8</td>
</tr>
<tr>
<td>Total poles above 5 cm mid-length diameter</td>
<td>No.</td>
<td>208</td>
<td>47*</td>
</tr>
<tr>
<td>Small wood (less than 5 cm) (withies and tops of large poles)</td>
<td>No.</td>
<td>335</td>
<td>231</td>
</tr>
<tr>
<td>Mean mid-length diameter of poles</td>
<td>cm</td>
<td>8.0</td>
<td>8.6</td>
</tr>
<tr>
<td>Mean heights to 5 cm top diameter</td>
<td>m</td>
<td>8.6</td>
<td>9.1</td>
</tr>
<tr>
<td>Solid volume of * poles over bark</td>
<td>m³/ha.</td>
<td>129.94</td>
<td>99.62</td>
</tr>
<tr>
<td>Stacked volume in 1 m billets</td>
<td>m³/ha.</td>
<td>188.86</td>
<td>147.97</td>
</tr>
</tbody>
</table>

* Seedlings from natural regeneration included in total

** Bark percentage approximately 15%**

figures were 43% and 37% respectively. It is apparent however, that volume production per tree was lower in treatment A than in treatment D, which is a disadvantage when the object of management is fuelwood production. The fall in volume production between treatments C and B is accounted for in both rotations by the larger diameters and taller trees in treatment C than in B, although treatment B had slightly more trees than C in both rotations, 3% and 11% respectively.

Conclusions
Results in both rotations show that any reduction in number of stems reduces fuelwood volumes. If stem diameter is an important object of management however, thinning of stands is recommended. In both rotations reducing to two stems gave significantly more fuelwood volume than reducing to three stems and the stems are also larger. Howland (1969) recommended to thin to three stems per stump because in his results this gave the highest volume production. Figures from the current study over two rotations do not
## Table 2
Summary of second Coppice Rotation
Coppice aged nine and a half years, Muguga, Kenya (measured 1982)

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>Units</th>
<th>TREATMENTS</th>
<th>L.S.D. (p=0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A No reduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B Reduced 3 stems</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C Reduced 2 stems</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D Reduced 1 stem</td>
<td></td>
</tr>
<tr>
<td>Live stumps Per cent</td>
<td>6.2</td>
<td>58</td>
<td>61</td>
</tr>
<tr>
<td>Proportion of stumps died during coppice rotation Per cent</td>
<td>12.7</td>
<td>14.7</td>
<td>17.6</td>
</tr>
<tr>
<td>Total poles above 5 cm mid-length diameter No.</td>
<td>226</td>
<td>163</td>
<td>145</td>
</tr>
<tr>
<td>Small wood (less than 5 cm) (withies and tops of large poles) No.</td>
<td>68*</td>
<td>24*</td>
<td>26*</td>
</tr>
<tr>
<td>Mean mid-length diameter of poles cm</td>
<td>9.1</td>
<td>9.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Mean heights to 5 cm top diameter m</td>
<td>12.2</td>
<td>12.9</td>
<td>14.5</td>
</tr>
<tr>
<td>Solid volume of ** poles over bark m³/ha.</td>
<td>387.56</td>
<td>314.81</td>
<td>341.01</td>
</tr>
<tr>
<td>Stacked volume in 1 m billets m³/ha.</td>
<td>408.64</td>
<td>339.15</td>
<td>371.07</td>
</tr>
</tbody>
</table>

* Seedlings from natural regeneration included in total
** Bark percentage approximately 15%

support these results as thinning to two stems produced more volume than thinning to three. Further work is required before conclusive recommendations can be made.

### Acknowledgements
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### Reference
Protection of Village Woodlots Against Goat Damage in Malawi by Mzoma R. Ngulube*

Summary
Both mechanical and chemical systems have been used to protect young tree seedlings from goat damage in village woodlots in Malawi. Traditional fences around whole woodlots have been effective, but are relatively expensive to maintain. Sisal living fences are recommended for village woodlots, as they are easy to establish, require low maintenance and are long lasting. Spraying a concoction of goat dung on seedlings although effective is expensive as repeated applications are required and therefore only practical with small numbers of trees. Several other thorny species are mentioned as potential live-fencing species.

Introduction
Newly planted seedlings are exposed to many harmful natural phenomena such as fire, disease, weed competition and drought. Experience, however, has shown that goat damage through browsing is one of the most important causes of damage to tree seedlings in most Malawian village woodlots. The damage mostly occurs during the dry season, when fodder is scarce and the animals are not tethered (tethering being mainly done during the rainy season to protect agricultural crops) and/or not strictly guarded. This problem is acute in areas with high goat populations where tethering is not even feasible (as fodder is scarce even during the rainy season) and guarding only restricted to crop gardens. In the Shire Valley and Mangochi areas, for example, bark stripping of already grown up eucalypts and *Gmelina arborea* trees by goats is common. As such, successful tree establishment in areas with high goat populations without any form of protection is not possible. This paper reviews methods which have been used to protect young trees from goat damage in Malawi. These methods may be classified as either mechanical or chemical.

Mechanical Methods
Fences are the commonest mechanical method used for protecting young trees against goat damage in Malawi. These may be divided into three broad groups:

- fences constructed around woodlots;
- fences constructed around individual trees; and
- living fences.

Fences around woodlots
Traditional fences constructed (using locally available material such as bamboo, grass and wooden posts) around whole woodlots have proved effective against goat damage wherever necessary. The main problem with such fences, however, is the constant attention to repair which is required until the trees have grown enough to be unaffected by browsing or completely out of reach of browsing animals. Where coppice management is required, the fences are either permanently maintained or reconstructed.

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as necessary. Wire fences (mesh or barbed) around woodlots, on the other hand, although as effective and more durable than traditional fences, are infrequently used. The initial costs of wire fences are too high for local farmers. Even those few who may afford the wire fences use them for other purposes such as animal enclosures and/or other things in combination with some trees (trees being secondary in most cases).

Fences around individual trees

Fences around individual trees are commonly used, especially in the Shire Valley, Mangochi, Nkhota-Kota and Salima areas to prevent seedlings from goat browsing. The fences are constructed in a form of cylindrical baskets (commonly made using split bamboos, reeds or even twigs) or just stakes or simply piling thorny branches around each seedling. Where stakes are used as guards, an open lattice work structure (but one which effectively excludes goats) is made to allow seedlings to be weeded without removal of the guards. Plastic mesh tubes or wire netting surrounding individual seedlings have been used elsewhere to provide effective protection of seedlings against animal damage (de Zwaan, 1977; Anthony, 1982). These devices however are also expensive for small-holder farmers and probably are no more effective than the cheap traditional methods.

Although individual tree guards have been used successfully in Malawi, they are obviously only suitable for protecting a limited number of trees. Their use is therefore limited to the establishment of fruit or ornamental trees around homesteads. Another problem which has been noted in areas where such devices have been used is that as soon as the leader protrudes through the top, it is totally unprotected and likely to be browsed as the rest of the tree is still protected. A browsed tip induces the formation of multiple leaders, tending then to turn the tree into a shrub which then has limited use for timber and polewood production. However, this can be rectified by constant inspection and then altering the devices accordingly. Another way is to use tall enough devices when establishing the seedlings. For example, simple bamboo tree guards, about 2m tall (canes split into two) were used effectively to protect Trema orientalis seedlings for 2 years from bushbuck browsing at Mazembe in Nkhata Bay District (Darwin, 1982; Barnett, 1987). However, whether fences around individual trees affect tree growth rates, as has been observed elsewhere (Anthony, 1982), is not known as this has not so far been evaluated in Malawi.

Living fences

A number of shrubs can be planted as living fences, the most suitable being those which grow fast and are thorny or have other repellent properties such as irritant sap (e.g. Euphobia tirucalli). In the Central Region of Malawi (especially in Dowa, Lilongwe and Ntchisi Districts) sisal (Agave angustifolia) fences have effectively been used to protect woodlots against goats. The IDRC-funded Rural Fuelwood and Poles research trials (Nkaonja, 1985) is an example. Prosopis juliflora has also been used in other trials as potential live fencing material, but its effectiveness has not yet been assessed. Other species which have been recommended for live fencing in Malawi (due to their thorny characteristics) include Acacia farnestiana, A. pennatula, A. tortilis, Haematoxylon brasiletto, Parkinsonia aculeata, Pithecellobium dulce and Ziziphus macronata (Ngulube, 1986). Caesalpinia decapetala has in the past been used as living fence material in many parts of the country, but this is no longer planted as it has been declared a weed in the country. The only disadvantage with living fences is that the fence should either be planted or established around the woodlot site (a year or more earlier depending on the growth rate of the fencing species) before the actual planting of the woodlot. In some
cases, a combination of traditional fencing and live fencing (until the living fence has established) has this problem. However, once established and properly managed, (proper trimming and filling gaps) living fences will form a permanent hedge.

Chemical Methods

Extensive research has been conducted elsewhere to identify an effective chemical animal repellent (Novellie and Bigalke, 1978; Shutz et al, 1978; Allan et al, 1984), but none has so far been found which is cost-effective for plantation conditions. The chemicals themselves are expensive and their effectiveness may vary with environment, depending possibly on the pest species, and some of them have been observed to be phytotoxic and/or reduce tree growth rates (Novellie and Bigalke, 1978; Shutz et al, 1978). These chemicals, even if found effective, would be too expensive for use in developing countries, let alone for small-holder farmers.

In Malawi, the most commonly used chemical recipe in rural areas consists of goat dung, which is crushed in a mortar and mixed well with water before being sprayed on the seedlings (using a wide-roused watering can). Like most chemical repellents, the major deficiency with this system is that the dung concoction protects only the particular foliage to which it adheres. New growth which appears after application is not protected and also rainfall may wash away the repellent (an especial problem in the 4-5 month rainy season). This is a critical shortcoming, since the leader represents nutritious new growth and is the most frequently browsed part of young trees. Repeated applications of the repellent, however, can alleviate the problem during the period required for trees to grow sufficiently to withstand browsing but this is, however, tedious and time consuming and as such, only practical with a small number of trees.

Conclusions

Goat browse problem is one which will definitely confront social foresters in village afforestation efforts in Malawi if the rural people participating in such programmes are not properly advised on effective protective measures. The various systems of protecting seedlings from goat damage reviewed here give both planners and participants involved in the current village woodlot projects in the country an opportunity to select the best system according to their experience and requirements. However, it must be noted that although traditional fences are effective and cheap to construct, they can be expensive and time consuming to maintain. Live fencing using sisal is probably the best for protecting seedlings from animal damage for a long period. Sisal fences are permanent, easy to establish and require minimal maintenance. Moreover, the rural people are already familiar with this species for sisal itself is frequently used in local construction as strapping material and in making strings; which may also be used for goat tethering as well. Other species as outlined in the text may also be assessed.

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References


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