EUCALYPTS FOR SOUTH-EAST ASIA

Richard L. WILLAN*

Summary

Figures are quoted for areas of eucalypt plantations throughout the world. South-east Asia accounts for only a small fraction of the world total. For the equatorial zone *Eucalyptus deglupta*, the only species which occurs naturally in the zone, is likely to be best adapted. For areas with a distinct dry season a wider range of species is suggested for testing. The importance of provenance is stressed. Among the silvicultural characteristics of the genus are its intolerance of competition and, in dry areas, the possibility of termite attack and boron deficiency. All can be overcome by appropriate treatment. The faster-growing species are capable of a mean annual increment of 25—30m^3/ha/an on average sites. For some purposes, especially fuelwood, specific gravity is no less important than volume production.

Introduction

At first sight it may seem strange that south-east Asia, the only part of the world outside Australia which has indigenous species of *Eucalyptus*, should have planted relatively small areas of the genus. During the preparation of the second edition of the FAO book "Eucalypts for planting", information was obtained on areas of eucalypt plantations established. Of the nearly 4 million ha of plantations reported, the biggest areas are 1.5 million in Latin America, 0.9 million in the Mediterranean basin, 0.8 million in Madagascar and Africa south of the Sahara and nearly 0.5 million in the Indian sub-continent.

In comparison, the areas of eucalypt plantations reported from south-east Asia are modest. Philippines had over 7,000 ha in 1975 and Papua New Guinea over 1,300 ha in 1973. An earlier estimate from Vietnam was 4,000 ha in 1965. Other countries in the area have trials or pilot plantations amounting to only a few hundred hectares. In countries in neighbouring regions there were 52,000 ha in the Kwantong Province of China in 1977 and over 8,000 ha in Sri Lanka in 1973. Within the tropical zone of the Pacific the biggest area, of about 12,000 ha, was (1976) in Hawaii.

The wealth of tropical rain forest in south-east Asia and the silvicultural dominance of another famous family, the dipterocarps, is one possible explanation for the small scale of eucalypt planting in the past. Another may have been the difficulty experienced in finding species of eucalypt suitable for local conditions. As population pressure increases and more land has to be transferred from forestry to agriculture, the need to supplement the resources of the natural forest by high yielding and intensively managed plantations becomes more urgent. A particular case is the planting of village woodlots for the provision of fuelwood and other products, mixed in an intimate mosaic with agricultural crops. This symbiosis of forestry with agriculture can provide substantial benefits to rural communities remote from the main forest areas. It seems certain that the rate of plantation establishment will need to be accelerated and it is worth re-examining the range of eucalypt species which could contribute.

* Senior Forestry Officer, Food and Agriculture Organization of the United Nations, Via delle Terme di Caracalla, 00100, Rome, Italy.

Choice of species

Table 1 summarizes the climate for a few representative stations in south-east Asia. Kuala Lumpur, Hinatuan and Djakarta are examples of equatorial climates in which there is little variation in temperature through the year and there is no month with less than 30 mm of rainfall. In Djakarta there is a period of 4 months during which monthly rainfall drops below 100 mm, while in Hinatuan and Kuala Lumpur at least 100 mm falls in every month of the year. Only one species of eucalypt is adapted to such a combination of uniform warm temperatures and absence of dry season—*E. deglupta*, unique for its occurrence on both sides of the equator from Mindanao at about 9°N to south-eastern Papua New Guinea at about 11°S. At altitudes close to sea level mean annual temperature exceeds 25°C, while at higher elevations (up to 1,800 m) it is between 20 and 25°. Total rainfall is mostly between 2,000 and 5,000 mm and there are no months with less than 30 mm. However, there are considerable variations in rainfall even within a single island. Cossalter (1977) notes that, in the central massif of Sulawesi, rainfall in an average year may reach 5,000 mm, with 11—12 months in receipt of over 100 mm, while in coastal areas adjacent to the Tomini gulf on the same island average rainfall is between 1,500 and 2,300 mm, with 4—5 months in receipt of less than 100 mm.

The discontinuous island distribution and the variations in temperature and rainfall reported suggest the importance of conducting provenance trials of *E. deglupta*. This has been confirmed by early results from trials in Papua New Guinea, where it was found that provenances from New Britain, Mindanao and Sulawesi grew better than local provenances from mainland Papua New Guinea. In eastern Mindanao, on the other hand, it was found that the local Mindanao provenance has been unaffected by a shoot borer which seriously damaged a Papua New Guinea provenance. *E. deglupta* is now being planted on an increasing scale in Mindanao and Papua New Guinea.

Where there is a distinct but not severe dry period in the cool season, a somewhat wider range of species may be well adapted to the conditions. First choice is the second of the two eucalypt species which does not occur on the Australian mainland—*E. urophylla*. The detailed account by Martin and Cossalter (1975/76) indicates the great variation within the species. Not only does it occur on several different islands in Indonesia (Timor, Flores, Wetar, Alor, Lomblen, Pantar, Adonara) but in Timor it occupies a wide altitudinal range from about 400 m to nearly 3,000 m. Considerable phenotypic variation occurs. In Timor rainfall is between 1,500 and 2,500 mm, with 2—4 months receiving less than 50 mm, but in the occurrences on other islands rainfall is usually between 700 and 1,500 mm with up to 7 or 8 months receiving less than 50 mm. The importance of provenance trials in this species also is clear.

The areas of the Australian mainland of most interest to south-east Asia are northern Queensland (especially the Cape York peninsula) and the northern part of the Northern Territory. Table 2 gives climatic data for some representative stations and the attached map, issued by the Director of Meteorology in Canberra, indicates the seasonal rainfall zones. The summer rainfall zones of over 1,200 mm and 650—1,200 mm have a good deal in common with some of the summer rainfall areas of south-east Asia. For example temperature range and rainfall distribution at Lamko and Mackay are not dissimilar; inland from Mackay the rainfall decreases rapidy with distance from the sea and a more exact matching of Lamko's climate could be found at an interior station. Other climatic similarities are between Lampang and Normanton; between Bangkok and Darwin; and between Manila and Cape York or Cape Don (although total rainfall at Manila is noticeably higher than at the other two stations).

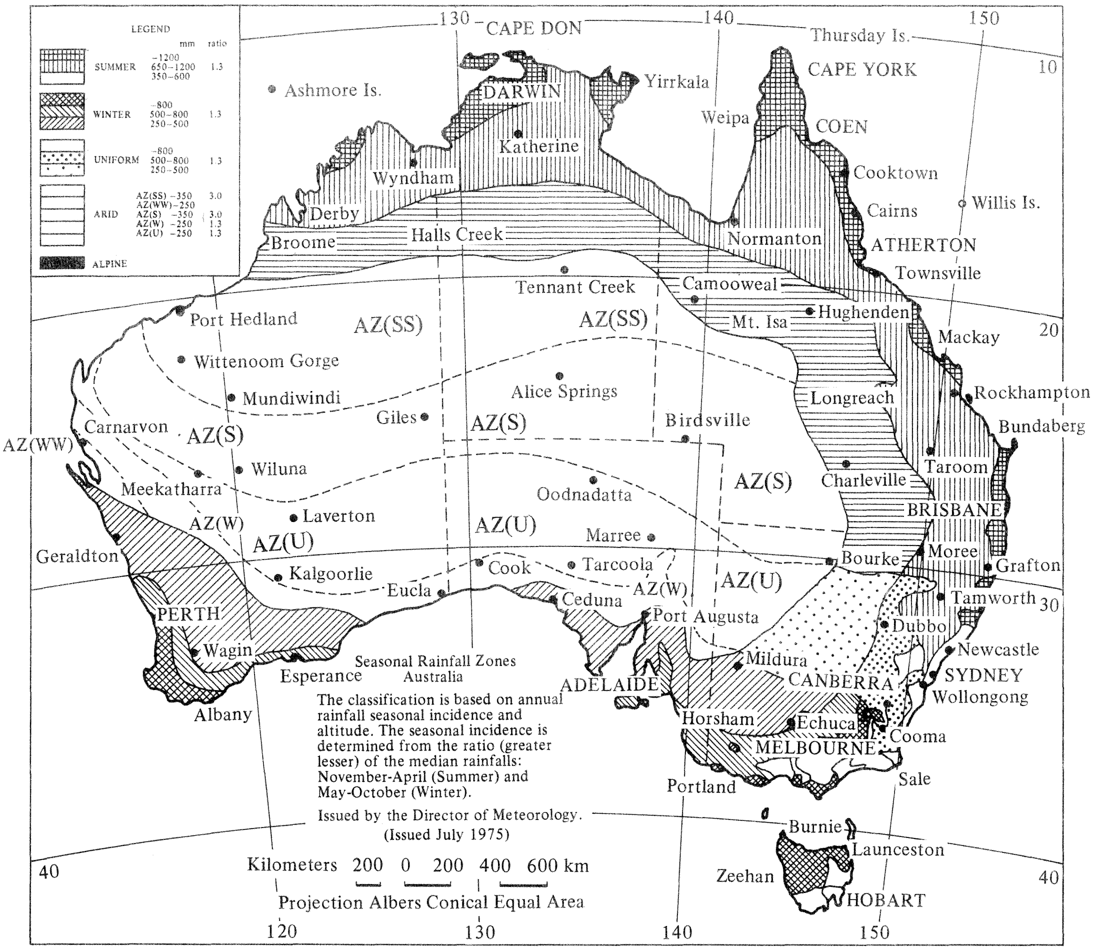
Eucalypts from these areas wich merit testing in south-east Asian areas with a dry season would include

Table 1 Climatic data for South-East Asia

	Mean temperatures (0°C)				Rainfall (mm)													Number of months	
	Annual	Hottest month	Coldest month	Difference	J	F	M	A	M	J	J	A	S	O	N	D	Total	"Dry" = ≤30mm	"Wet" = >100mm
1) LAMKO, China Lat. 20°00'N Alt. 4m	24	29	18	11	14	19	27	47	82	127	215	233	227	129	55	26	1,201	4	5
2) LAMPANG, Thailand Lat. 18°15'N Alt. 220m	26	29	22	7	7	9	23	71	136	128	129	190	203	123	23	5	1,047	5	6
3) BANGKOK, Thailand Lat. 13°44'N Alt. 2m	28	30	26	4	9	25	34	89	166	168	180	178	289	253	57	7	1,455	3	6
4) MANILA, Philippines Lat. 14°31'N Alt. 19m	27	29	25	4	23	11	17	32	128	252	413	437	353	196	138	68	2,068	3	7
5) HINATUAN, Philippines Lat. 8°22'N Alt. 4m	27	27	26	1	724	427	460	322	295	220	218	199	195	209	371	664	4,304	0	12
6) KUALA LUMPUR, Malaysia Lat. 3°09'N Alt. 38m	26	27	26	1	170	167	238	276	213	127	108	161	189	278	262	230	2,419	0	12
7) DJAKARTA, Indonesia Lat. 6°11'S Alt. 8m	26	27	26	1	308	312	199	131	103	87	60	40	69	112	137	212	1,770	0	8
8) SURABAJA, Indonesia Lat. 7°16'S Alt. 7m	27	28	26	2	313	292	267	187	110	88	47	13	13	38	118	249	1,735	2	7
9) KUPANG, Indonesia Lat. 10°10'S Alt. 45m	27	28	25	3	386	347	234	65	30	10	5	2	2	17	83	232	1,027	6	4

Table 2 Climatic data for Northern Australia

	Mean Temperatures (0°C) Annual	Hottest month	Coldest month	Difference	Rainfall (mm) J	F	M	A	M	J	J	A	S	O	N	D	Total	Number of months "Dry" = ⩽30mm	"Wet" = >100mm
1) CAPE YORK, Queensland Lat. 10°43'S Alt. 27m	26	27	24	3	377	350	404	278	66	24	19	8	5	9	41	200	1,781	5	5
2) CAPE DON, Northern Territory Lat. 11°20'S Alt. 19m	27	29	25	4	292	226	274	139	17	3	2	1	3	20	102	220	1,299	6	6
3) DARWIN, Northern Territory Lat. 12°28'S Alt. 30m	28	30	25	5	391	330	260	103	14	3	1	2	13	50	126	243	1,536	5	6
4) COEN, Queensland Lat. 13°57'S Alt. 609m	25	28	22	6	273	266	247	94	12	9	6	4	2	12	52	159	1,136	6	4
5) CAIRNS, Queensland Lat. 16°55'S Alt. 5m	25	28	21	7	421	422	460	264	110	72	39	42	43	50	98	203	2,224	0	6
6) ATHERTON, Queensland Lat. 17°17'S Alt. 753m	20	24	16	8	297	313	249	108	60	46	29	24	23	27	75	174	1,425	4	5
7) NORMANTON, Queensland Lat. 17°39'S Alt. 9m	27	31	22	9	268	261	157	32	8	10	4	2	3	10	44	146	945	6	4
8) MACKAY, Queensland Lat. 21°09'S Alt. 11m	22	27	17	10	360	335	304	156	95	66	38	28	36	47	74	163	1,702	1	5



A. Species with a wide distribution in north Queensland/Northern Territory (provenance testing may be desirable)

E. alba	occurs also in Papua New Guinea and in Lesser Sunda Islands
E. brassiana	occurs also in Papua New Guinea
E. confertiflora	occurs also in Papua New Guinea
E. miniata	
E. papuana	occurs also in Papua New Guinea
E. polycarpa	occurs also in Papua New Guinea
E. tetrodonta	

B. Species with restricted distribution in north Queensland/Northern Territory

E. nesophila	Melville and Bathurst Islands, Coburg peninsula
E. torelliana	Cairns/Atherton area. Casts the densest shade of any eucalypt and reputed to be the only species capable of growing in rain forest.

C. Species which have a wide distribution in less tropical areas in Australia. Essential to test only the northern provenances

E. camaldulensis	for provenance trial results, see Lacaze 1970, 1978.
E. citriodora	one of the successful species in Kwantong Province, China.
E. cloeziana	
E. drepanophylla	
E. exserta	one of the successful species in Kwantong Province China.
E. grandis	from latitude of Atherton
E. pellita	Cape York peninsula provenance
E. teleticornis	also occurs in Papua New Guinea.

The above species list assumes planting at low or moderate elevations. Planting at high elevations would allow the use of more temperate species or provenances, e.g. southerly provenances of *E. grandis, E. robusta, E. saligna, E. paniculata.* In the Nilgiri Hills in southern India, latitude 11°N and elevation 2,000 m, *E. globulus* from the uniform or winter rainfall zones of Australia has performed outstandingly for over a century.

Precision in climatic matching should not be carried too far. Most species and provenances have some degree of plasticity, a capacity to adapt to environments which differ somewhat from the natural one. Assessment of plasticity is one of the purposes of species and provenance trials.

Silvicultural techniques

All species of eucalypts are extremely intolerant of competition, especially from grass, and show a corresponding response to careful site preparation and clean weeding. Less intensive techniques, which may give satisfactory results with more tolerant genera such as *Tectona* or *Pinus*, are likely to fail with eucalypts. The higher cost of intensive site preparation and weeding can be justified if it produces a fully stocked plantation with closed canopy within 18 months, which is perfectly possible with a fast-growing species.

In many parts of Africa eucalypts cannot be successfully planted without special insecticidal treatment against termites. Such treatment is accepted as an essential part of establishment costs. Termite damage is usually confined to the drier savanna areas. In the wetter parts of south-east Asia termites are unlikely to pose a problem, but application of insecticide could be necessary in dry areas.

Response to NPK fertilizers varies greatly according to the fertility of the site. On some sites response does not justify the cost. In Africa savanna areas, however, an initial application of boron at or soon after planting is essential to prevent severe deficiency symptoms including dieback during the dry season. Similar problems are unlikely to arise in the wetter parts of south-east Asia but could do so in dry areas.

The coppicing ability of many eucalypt species e.g. *E. grandis, E. globulus* is a big advantage when the crop is being managed on short rotations for production of fuelwood, poles or pulpwood. Unfortunately *E. deglupta* is reported to be a poor coppicer.

Potential yields

Information on yields of most of the species listed above is lacking. As an indication of what can be expected from one of the fastest-growing species, *E. grandis*, yield tables from Uganda, Zambia and South Africa agree in predicting an MAI of between 25 and 30 m^3/ha/an on the sites of medium quality which may be expected to make up the greatest part of their planting areas. Similar yields may be expected from a few other species e.g. *E. urophylla* and *E. deglupta*. In the Philippines an overall average of 17—25 m^3 is expected from the latter species (Tagudar 1974) while one sample plot in Papua New Guinea yielded 31 m^3 at age 12—15 (Ovington 1972). It is doubtful whether any of the other species listed will yield as much as these three, although the better provenances of *E.*

camaldulensis, *E. tereticornis* and the closely related *E. brassiana* should yield 15—25 m^3.

For many purposes volume yield is not an adequate measure of productivity. This is particularly the case for fuelwood, since calorific value is closely related to specific gravity. Weight production is therefore more important than volume production. A comparison of oven-dry density (gm/cm^3) of several eucalypt species from young plantations in Congo (Martin and Cossalter 1975/76) gave figures of 0.46 for *E. deglupta*, 0.52 for *E. urophylla* and *E. saligna*, 0.58 for *E. robusta*, 0.69 for *E. cloeziana* and 0.73 for *E. citriodora*. This implies that an MAI of 18 m^3 of *E. citriodora* has about the same calorific value as an MAI of 29 m^3 of *E. deglupta*. Similar comparisons can be made with other genera. The "Hawaiian giant" variety of *Leucaena leucocephala* is quoted as 0.54, while the common, slower-growing, variety of the same species is quoted as 0.70 (N.A.S. 1977). Another fast-growing species *Albizia falcataria* is quoted as varying between 0.25 and 0.4 (Fenton *et al* 1977).

The above examples are illustrative only. Specific gravity within a species may vary greatly, being affected by provenance, individual genotype, age, site type or silvicultural treatment. For this reason assessment of specific gravity *under local conditions* is essential.

Conclusions

It is not claimed that *Eucalyptus* is the panacea for afforestation problems in south-east Asia, still less for forestry as a whole. Nevertheless it would appear that the genus could contribute more in the future than it has in the past. For the wet equatorial zone *Eucalyptus deglupta* is the species to be preferred, for the drier areas there are a number of other species worth trial. Provenance differences have been demonstrated in several of these species and careful attention should be paid to the selection and testing of provenances. Where plantations are for fuelwood production, e.g. in village woodlots, specific gravity is as important as volume production.

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Discussion

Domingo, I. L. (The Philippines): Not only Papua New Guinea provenance of *Eucalyptus deglupta* but also Mindanao provenances are being attacked by a borer in our plantations. Is there any *Eucalyptus* species that tolerates high pH?

Answer: *E. gomphocephala* is one species which is known to be tolerant of calcareous soils with high pH. In the Mediterranean areas it has grown well on calcareous soils where *E. camaldulensis* has been unhealthy and chlorotic. However, *E. gomphocephala* is a winter rainfall species. I do not know of a summer rainfall species that is tolerant of high pH.

Liew T. C. (Malaysia): 1) In Sabah, at least 10,000 acres of *E. deglupta* have been planted. The seed source of this species originated from Papua New Guinea. The trees have been attacked by the larva of a moth (Carpenter moth) which is being identified at Kyoto University. The larvae attack the cambium, bore holes, hence causing the top part of the tree to collapse. The incidence of the attacks is about 10%. Have similar attacks been reported elsewhere? 2) Is FAO arranging for further provenance trials of *E. deglupta* in Southeast Asia in the form of seed supply?

Answer: 1) I think that similar attacks have been reported from British Solomon islands and from Fiji. 2) *E. deglupta* seed of several provenances for provenance trials should be available from Division of Forest Research, CSIRO, Canberra, Australia.

Willian, R. L. (FAO): I would like to ask Dr. Domingo if it is true that *Eucalyptus deglupta* is a poor coppicer.

Domingo, I. L. (The Philippines): Yes, it is, especially if the area is not clear cut. This is in contrast with *Albizzia falcata* which is a good coppicer.

Tun Hla (Burma): 1) *E. camaldulensis* grows well in Burma and plantations supply fire-wood and serve as protection trees. We would like to introduce *Eucalyptus tereticornis*. May I know what are the differences between the two species? 2) We also grow *Eucalyptus grandis* in Shan State for soil conservation. After the second or third year of growth termites attack the root of the trees which are gradually destroyed. Is it possible to control such attacks?

Answer: 1) *E. tereticornis* and *E. camaldulensis* are distinct but fairly closely related species. Both exhibit large provenance difference and provenance trials of both are desirable. On the whole it may be said that the most drought-resistant provenance of *E. camaldulensis* (which has the wider distribution of the two) will withstand more arid conditions than any provenance of *E. tereticornis*, but that the best provenances of *E. tereticornis* grow straighter than *E. camaldulensis*. 2) *E. grandis* is considerably less drought-resistant than *E. camaldulensis*, so deaths may be due primarily to drought-stress, the termite attack being secondary. A possible alternative explanation could be the formation of a "bridge" of untreated soil above the pot soil, allowing access for the termites to the plant roots.

Arihara, M. (Japan): Could you indicate some examples of pest damage to *Eucalyptus* trees?

Answer: Examples are: 1) The long-horn borer *Phoracantha punctata* attacking and killing trees. Usually considered secondary pathogen following drought stress. Attack may be lessened by use of trap-trees, burnt after larvae have hatched and before they have pupated. 2) *Gonipterus Scutellatus* a defoliator which can be easily controlled by a parasite. 3) Fungus *Diaporthe* which causes stem cankers and death of trees through cambial attack in humid areas. It is difficult to control it and it is best to prevent it by choosing species which are suited to the climate and therefore resistant to the fungus.