THE ESTABLISHMENT OF *PINUS CARIBAEA* (var. *HONDURENSIS*) IN FIJI — AIMS AND TECHNIQUES

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SYNOPSIS

In an attempt to diversify the Fijian economy. create employment, and utilize the large areas of unproductive grasslands on the western sides of both Viti Levu and Vanua Levu, the Fiji government is proceeding with a very ambitious Pinus caribaea *afforestation programme. The Fiji Pine Scheme was inaugurated in 1972 to implement this aim and although still in the early stages of development, present progress is favourable. This paper endeavours to give relevant background information and describe the techniques developed.*

INTRODUCTION

Fiji's internal demand for timber is met by a combination of imports and utilization of indigenous forests.

Initially the establishment of *Pinus caribaea*† was an endeavour to supply the domestic requirements of sawntimber and other wood products: hence to reduce the amount of overseas expenditure and provide against the time when indigenous supplies become inaccessible or exhausted round the year 2000. Trials, over a period of five years, indicated that this species had successful growth potential under local conditions. Plantings were initiated in 1961 when 6.5 ha were established at Lololo with a gradual annual increase reaching 486 ha in 1969. By this time the obvious potential for forestry in Fiji had been realized and a request for assistance from the United Nations Development Programme was formulated. Feasibility studies were carried out during 1969-71 with special emphasis placed on the future expansion of *Pinus caribaea* plantations. These studies concluded that there was a tremendous opportunity to expand and develop existing plantations with the aim of developing a wood chip and eventually a wood pulp export industry (FAO, 1972). It is envisaged that this chipwood industry will be productive by 1983. As an integral part of the regime, local demands for sawlogs and round wood produce will be catered for.

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†*Pinus caribaea* (var. *hondurensis*) throughout unless otherwise stated.

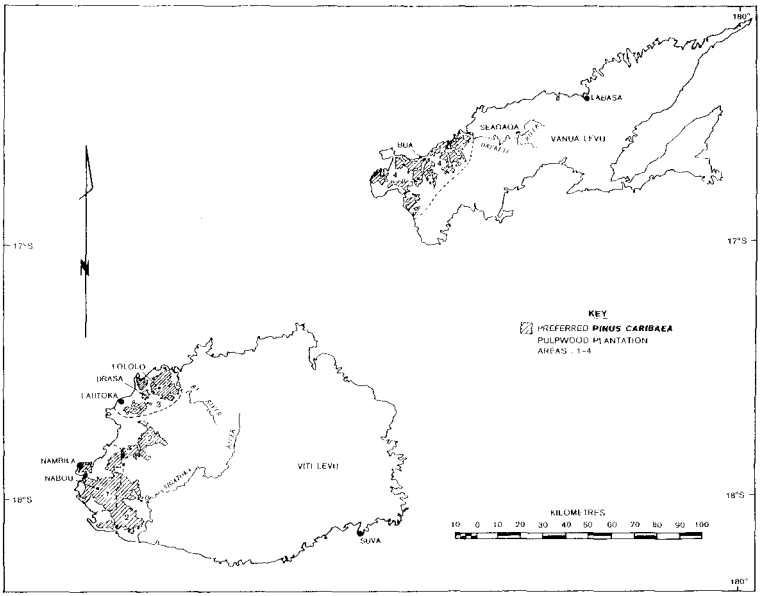

FIG. 1: *Map of the two main islands of Fiji showing the location of preferred* Pinus caribaea *pulpwood plantation areas.*

There are certain prerequisites to the success of the Pine Scheme. First, the urgent establishment of 20 000 ha, this being recognized as the minimum economic scale for entry into an export chipwood market (Hansen, 1972), to be completed by 1978. Secondly, initial planting must be concentrated at Drasa/Lololo and Nabou in western Viti Levu, both areas being close to the proposed deep water port at Nabila (see Fig. 1).

Fiji, being a developing country, finds the financing and staffing of major undertakings, such as this, a drain on its internal resources. New Zealand has taken a very active part in the development of the Pine Scheme, from both the economic and staffing aspects. All building materials and nursery equipment used on the new forest station at Nabou, and the Scheme's new office at Lautoka, are being purchased through the New Zealand aid programme. Experienced personnel in the way of a forest ranger, surveyor, engineer, mechanical supervisor and administrative officer have been seconded through the Colombo plan. These officers are assisting with day-to-day administration within the scheme and also providing on-job training for local staff.

PLANTATION AREAS

Past plantings of *Pinus caribaea* have been centred around the Drasa/Lololo forest, which at present consists of some 6470 ha. Of this total, 243 ha is a Cuban provenance of *Pinus*

caribaea. Although not as vigorous as var. *hondurensis* it is of better form. The reason why more of this strain is not being planted is the lack of a constant seed source. Recent research in Australia indicates that it is particularly suited to the Northern Territories; Fiji's area could therefore be a potential revenue earner through an export seed trade.

The total overall land area capable of growing *Pinus caribaea* is approximately 99 000 ha of which 54 000 ha can be defined as being the most economically attractive at this time. The immediate priority is to establish 20 000ha.

The 54 000 ha referred to above falls into four defined areas:

Area I	Around Nabila, western Viti Levu	13 000 ha
Area II	In the hinterland behind Nabila	16 500
Area III	Drasa/Lololo, near Lautoka, western Viti Levu	8 300
Area IV	Bua, south western Vanua Levu	16 000
		54 000

The reason for the selection of these areas is that they are close to Nabila, relatively infertile, grossly unproductive, and subject to severe erosion through constant burning.

Topography is generally suited to forestry with only a small percentage of the total area over 600 m above sea level. Areas I, II and IV are of easy, undulating country, while area III ranges from moderately steep to steep and quite broken in parts.

The major soil types are ferruginous latosols, red-yellow podzolics and areas of nigrescent soils. There is some doubt as to whether nigrescent soils can sustain a high increment crop of *Pinus caribaea* (Humphreys, 1972) and research is under way to evaluate this problem.

Over and above areas I to IV, there is a strong possibility that groups of villages will be encouraged to plant their idle grasslands. For obvious reasons, control of such a venture would come under the jurisdiction of the Pine Scheme and might be implemented through a system of subsidies.

NURSERY PRACTICE

At present all seed is imported from British Honduras and Guatemala. Local collections are being made successfully and Fiji should be self-sufficient by 1977. A tree improvement section has been established and is active in developing seed orchards aimed at producing high quality seed.

A phased sowing programme is prescribed at two-weekly intervals and a potted system used to raise nursery stock. The need for a potted system arises because Fiji does not experience a non-growing season; planting is dictated by amounts of rain and climatic factors. Evaporation rate is extremely high if dry spells occur at this time and conditions are not conducive to bare root planting.

The first sowing phase is carried out in mid-June with the aim of providing a good healthy 200 mm to 300 mm seedling

by the time the first rains allow for planting in November or December.

Two distinct nursery operations may be recognized:

(1) Preparation of seedbeds and sowing.

(2) Preparation of pots and transplanting of seedlings.

Seedbeds are 1 m wide and as long as required. They are raised by filling with 100 mm of pure sand with an overlying 25 mm of fine gravel. Beds are then sterilized with methyl bromide gas against fungal attack at the rate of 450 g/3 m^3 of bed soil and this is carried out before each sowing. Fine gravel in seedbeds is renewed every year.

Seed is broadcast sown at the rate of 450 g/4.6 m^2 of bed, covered to twice its own depth with sand, and firmed with a firming board.

Ten to fourteen days after germination the seedlings are pricked out into a container of water and immediately transplanted into soil-filled polythene pots. This is timed to minimize losses as the plants are still in the cotyledon stage and there is no evidence of side roots.

The complete operation is carried out as quickly as possible under nylon mesh which provides 65% shade. Newly pricked out seedlings are shaded for three days; this reduces the shock of removing seedlings from shaded seedbeds into direct sunlight and creates favourable working conditions for labour engaged on this operation.

Soil for the pots is of a well-structured valley bottom type. At the soil source all surface vegetation is removed and the exposed topsoil lifted and passed through a shredder (Pneulec No. 2). It is then conveyed to the nursery and unloaded directly into wooden fumigation bays where it is sterilized with methyl bromide gas (in this case to kill weed seeds as well as for fungal control) at the rate of 900 g/2.8 m^3 for 24 hours. Pots are then manually filled and stacked in bays where superphosphate and sulphate of potash are added, in solution, at the rate of 57 g/0.02 m^3 of soil. A 24-hour period elapses before the prepared pots are treated with a copper oxychloride solution specifically against the incidence of damping-off. This solution is applied at the rate of 28 g to 4.5 litres of water and followed directly by transplanting.

The current pot size is 38 mm in diameter, 127 mm long and 0.002 gauge. Bays are 27 m long and 1 m wide with cross-wire supports at 1.5 m intervals, each bay accommodating approximately 20 000 pots. A layer of polythene is laid on the ground to inhibit weed growth between the pots and prevent root penetration. Water is applied as required by sprinkler system, the amount being reduced as planting out time approaches in an attempt to produce a hardy seedling.

Mice cause damage to seeds and newly germinated seedlings, therefore pre-baiting with "Ratsack" concentrate mixed with a cereal is carried out six to eight weeks before the first sowing is scheduled. Frogs cause damage by crushing seedlings in the pots and the nursery is enclosed with a frog-proof fence.

The system as it stands is satisfactory but in the interest of economics an active research programme into soil mixtures, nursery weedicides, bare root planting and direct sowing into pots is in progress. The use of methyl bromide gas is standard practice but because of the dangerous nature of this product alternative soil sterilants are being tested.

LAND PREPARATION AND ESTABLISHMENT

The main vegetation types encountered are mission grass *(Pennisetum polystachyon)*, fern *(Gleichenia linearis)*, reed *(Miscanthus floridulus)* and a native conifer, nokonoko *(Casuarina equisetifolia)*. Mission grass is the predominant ground cover followed by fern. However, it is not uncommon to find areas where all four are present.

Areas to be planted are burned off in order to clear the ground of vegetation, thus making all aspects of planting easier, cheaper and safer. Where no local sales can be found for nokonoko, this tree is poisoned with a 2,4,5,-T/diesel mixture prior to burning.

Mission grass and reeds are very highly inflammable and great care is taken in the siting and preparation of fire-breaks. These are, in the main. formed manually using cane knives, are about 10 m wide, and are situated where the fire is expected to lose momentum. The burning system is very similar to that used in New Zealand.

Planting is carried out during the wet months of November to March and is therefore restricted. As the yearly planting area increases, speed becomes of the utmost importance. To this end poling, pitting (cultivation of planting holes with post-hole spade) and construction of access roads are carried out well beforehand.

Plants are carted from the nursery to pre-determined plant dumps. From the dumps trees are distributed by special gangs using 300 mm × 300 mm tin trays each holding approximately sixty plants, thus leaving the planters free from this chore. The polythene pots are removed after a hole has been dug in the pre-cultivated pit. Planting espacement is currently 3 m × 3 m and plants are placed so that as much as 50 to 75 mm above the root collar is covered, then firmed. This is necessary as high winds and rains, which tend to loosen seedlings, are experienced throughout the planting season. Contract and incentive schemes are mainly used. The establishment of 250 plants constitutes an average working day per man.

Mortality assessments (10% sampling) are carried out six months after planting and to date survivals of 80 to 90% are normal.

TENDING

Because of the exceptionally quick regrowth of mission grass and reed, the main tending operation is release cutting. This is usually carried out once in the year of planting and

twice during the second year of growth, by which time the tree (average height 2 m) is considered to be free of competing grass (Fig. 2). Reed areas need added attention and release cutting could be required as much as three times a year for the first three years. Fortunately, this type of vegetation occurs only in small isolated patches.

Pruning is a dual-purpose operation, first to reduce the chance of a crown fire by removing fuel the fire would utilize to climb the tree and, secondly, to produce improved quality sawn timber. Although not evaluated, a pruning regime has

FIG. 2: *An exceptionally good stand of 2½-year-old* Pinus caribaea. *This area was severely toppled and propped successfully.*

Fiji Pine Scheme photograph by A. Rodgers

been initiated and will be amended as additional data become available. The following is the present pruning schedule:

At age 4½ years prune to 3 m all trees over 6 m height.

At age 6½ years on a selected 370 stems per hectare the pruning lift is extended to 7 m.

Thinning of pole material is carried out to supply local demand and produce is treated, under pressure, at the Drasa Tanalith treatment plant.

EXPECTED YIELDS

The very few early permanent sample plots are twelve years old, scattered and on a variety of soil types. It is therefore not surprising that there is presently a severe lack of mensurational data available for predictions of future yields. Mensuration consultants who carried out development and feasibility studies used all information gathered up to the end of 1969 and concluded that an average merchantable M.A.I. of 17.5 m^3/ha could be attained. This assumption estimates a mean dominant height of 23 m and a basal area of 41.3 m^2/ha at age 15. However, recent measurements of sample plots (1971) and calculations carried out by the Commonwealth Forestry Institute at Oxford indicate that the 1969 findings are underestimates. The Institute's calculations give a mean dominant height of 24.4 m and a basal area of 43.6 m^2/ha at age 15. On these estimates it is calculated that the average merchantable M.A.I. will be 19.6 m^3/ha, hence an average merchantable volume of 294 m^3/ha.

The need for quick answers to this problem is understood and a comprehensive annual permanent sample plot programme is being carried out. Figures will be used to constantly review and update data.

Data from permanent sample plots of *Pinus caribaea* measured and calculated during 1971 are shown in Table 1.

GENERAL DISCUSSION

Although present progress indicates a high degree of success in this venture, there are certain vulnerable aspects of the Pine Scheme, namely, land acquisition, continuity of trained staff, adverse weather conditions, fire, and overseas aid.

Whilst real improvements have been made over the past year, land leasing is still a slow process. A large proportion of all land in Fiji is owned by the Fijian people and administered by the Native Land Trust Board. Negotiations over the major land areas are dictated by the attiudes of the land-owners. The Pine Scheme includes an active forestry educational programme in the villages in an attempt to speed up these legalities and the whole process is showing signs of becoming more streamlined.

At the present rate of progress, the provision of trained staff will be of major importance. The secondment of ex-

TABLE 1: PERMANENT SAMPLE PLOTS OF *PINUS CARIBAEA* MEASURED AND COMPUTED MID-1971

Location and Plot No.	*Age (yr)*	*No. Stems/ha*	*Basal Area/ha (m^2)*	*Dominant Height (m)*	*Standing Volume/ha (m^3)*
Seaqaqa:					
70	11½	544	25.7	22.6	188.2
78	10½	581	23.4	19.2	163.7
77	10½	568	18.1	18.3	106.3
71	9½	679	25.0	18.3	154.6
72	9½	679	26.6	18.9	170.0
67	8½	642	25.5	18.9	162.3
66	8½	852	23.4	15.9	126.6
Nausori Highland:					
45	10½	803	39.2	21.3	254.7
46	10½	605	28.0	18.0	168.6
47	9½	865	31.4	18.6	199.4
48	9½	840	29.4	17.7	173.5
49	8½	803	29.8	15.9	165.8
50	8½	951	22.5	16.2	110.6
Drasa:					
65	10½	939	10.8	14.0	48.9
99A	10½	544	16.5	19.2	98.6
98A	10½	519	17.9	18.6	116.1
39	9½	902	23.9	16.8	130.1
40	9½	704	19.3	18.9	121.0
41	8½	741	17.2	16.8	92.3
42	8½	655	14.2	17.1	70.6

(From Smart, 1972; volumes were derived from a new single tree volume table using the most up-to-date mensurational data and prepared by the Commonwealth Forestry Institute, Oxford.)

perienced officers from New Zealand is commendable but the government's localization programme treats this as an interim measure. Junior staff vacancies for the Scheme are filled by students from the Forestry Training Schol at Lololo. However, to gain full benefits, these trainees should continue their training under personnel experienced in large-scale exotic afforestation and it is at this middle management level that the scheme lacks strength.

Suggestions put forward by Levy and Usmar (1972) that New Zealand take an interest in the training programme and organize tours of duty to New Zealand for selected local staff, with the possibility of choice trainees passing through the New Zealand Ranger School, are sound. Two Pine Scheme trainees are at present studying forest engineering and surveying at Rotorua.

Fiji is in the unfortunate geographical latitudes where high winds, often reaching hurricane force, are experienced. A recent hurricane (stated as being the worst ever to strike Fiji) showed that most age classes are subject to severe toppling. Probably because of the high rainfall at the time, no great degree of breakage was recorded. Surprisingly, prop-

ped younger stands now show no signs of having been toppled while older windthrown trees are generally growing very well, even those lying on the ground. However, this does not detract from the fact that the effects of future hurricanes on a fully mature crop could be critical.

Fire is also a potential danger. Areas selected for future development are located in the dry zones on both main islands and covered with highly combustible vegetation. It is not uncommon for those zones to experience drought conditions between the months of May and September. Figures extracted from the Pine Scheme Working Plan and pertaining to proposed planting areas show that during the dry season the average monthly rainfall is not more than 75 mm, associated with high daytime temperatures (average 26° C) and drying winds. There are small pockets of sugarcane farms throughout the Drasa/Lololo forest and seasonal burning of this crop creates a serious threat to the safety of the forest. Recent legislation has given the Pine Scheme stricter control over burning within, and immediately surrounding, forested areas. Moreover, an active and sustained public education programme, as well as continuous vigilance, is required if disastrous fires are to be avoided.

As a developing country, Fiji receives considerable assistance through overseas aid programmes. The world interest shown in the Pine Scheme is far-reaching. New Zealand is supplying building materials, experienced personnel and monetary contributions. Australia is giving fire tankers, radios and vehicles, and Canada has expressed interest in the establishment of a *Pinus caribaea* research centre in Fiji. The World Food and Agricultural Organisation is still allied to the project, even to the stage of proposing it be an FAO undertaking. However, Fiji has opted to keep complete control and its financial contributions by far outweigh those of outside parties. If any aid programme contributing directly to the Pine Scheme withdrew, future progress would be hampered.

CONCLUSIONS

Because of the instability of Fiji's main revenue earners, sugar, gold, copra, and the inconstancy of tourism, the Fiji Pine Scheme has been given such a priority that it is a complete unit, divorced from the Forestry department and responsible directly to the Prime Minister.

The Pine Scheme is unusual in that it is based on a high degree of certainty that price levels and marketing potential will remain healthy for a considerable time. Fiji also has the added advantage of having developed a proven technique for growing softwoods on a commercial scale under tropical conditions. These two factors, when related to the large areas of already cleared land available in close proximity to potential export points, ensure that forestry in Fiji is a welcome addition to the economic and social structure.

The Fiji government has shown considerable foresight in introducing this sizable venture at this time. It is hoped that the present sound progress will continue and that a large-scale, fully integrated, timber industry will develop.

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