The Balsa Manual

TECHNIQUES FOR ESTABLISHMENT & THE MANAGEMENT OF BALSA (Ochroma lagopus) PLANTATIONS IN PAPUA NEW GUINEA

ITTO East New Britain
Balsa Industry Strengthening Project
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ACKNOWLEDGEMENTS

This manual is based on experience gained in the field covering a span of some 35 years. Under the ITTO project, the last five years (1996-2001) have been most productive in terms of gathering new information upon which to base this manual and to make changes to the silvicultural and management techniques for Balsa. Most of earlier useful records on Balsa and documentation from trials and yield plots were either lost in the Rabaul volcanic eruption of September 1994 or could not be retrieved from other archival sources.

This latest input of information would not have been possible without the assistance and comments from the ITTO Project support staff, in particular the Balsa Project officer, Mr. John Ohana, and Miss Becky Wilson, one of our former typists and secretary, who also assisted us in the field during plot measures. Miss Ruth Geob, a more recent addition to the Project's staff as the nursery officer, has also assisted, and Mrs Lydia Tameta our typist for doing the correction typing. To all of them my sincerest appreciation.

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PREFACE

The last update of the Papua New Guinea Forest Service publication on the silviculture of Balsa by White and Cameron (1965), was in 1972. This was encapsulated in a few brief pages in a silvicultural manual for a number of indigenous and exotic commercial tree species used for reforestation in Papua New Guinea (PNG). Although a useful publication, the recommended management and the thinning schedules were never put into practice and Balsa was grown and treated much in the manner that one would grow an agricultural crop like sugar cane. Based on Forestry experience, it was obvious that the local growers with large Balsa blocks were not getting the maximum yield and financial returns from their blocks, albeit they were still making a profit. It was obvious that attitudes towards Balsa establishment and management had to be changed and that a new manual was required to address this need.

Initially, the last publication which is now out of print, was used as the basis for the new manual. This work started in the 1990's. However, with metrication, new field information and changes in the nursery and field establishment and management techniques by the East New Britain ITTO Balsa Industry Strengthening Project between 1996 to the end of 2001, the production of the manual was delayed until the present. The new manual has now improved upon and altered much of the past information. The manual contents have also been expanded in response to the many requests for information and guidance from the growers and the industry in PNG.

Responding to the need for better use of the Balsa resources introduced into PNG, the manual includes for the first time, sections dealing with seed collection, documentation and handling, seed sources, the use of Balsa seedling seed orchards, as well as seed tree selection for tree improvement purposes and for the conservation of the genetic resource. Such activities have not been previously practiced in the silviculture of Balsa in PNG and adds a new dimension to the Balsa Industry which has been long overdue.

At many levels of the Balsa growing community, verbal and written descriptions are sometimes not enough to outline techniques or situations in the establishment and management of Balsa and change for the local growers and private commercial companies does not come easily. To address this, particularly for the local growers, the "Luk Save" or "Look and Learn" approach has been used in the new manual by including photos and illustrations to demonstrate important features and activities covered in some sections of the manual.

Currently the new silviculture techniques are being adopted throughout East New Britain. Many village Balsa growers have also adopted their own method of establishing Balsa such as the use of triangular planting and the use of minimum management. Many of the older growers may not change their ways and in the preparation of the manual, this has been taken into account and the manual's management and thinning schedules are flexible enough to be adapted or modified to suit such situations and will be still useful to these people, as well as serving future generations of Balsa growers. Although this manual deals specifically with the establishment and management of Balsa in PNG and the problems outlined herein may be specific to PNG, the techniques outlined may also be adaptable in other countries wishing to grow Balsa.

THE BALSA MANUAL

1.0 HISTORICAL INTRODUCTION

Seed of Balsa ***Ochroma lagopus*** *(Swartz.)* was first imported into East New Britain, PNG prior to 1938 (Anon 1938) and the second was made by Milner's Balsawood (now Australian Balsa) in 1946. There is no record of any surviving trees from these first two importations (Unpublished Departmental Paper). Between 1947 and 1974, ten introductions of Balsa were made into PNG and from these nine sources were successfully established in trial plantings (appendix 1).

A second species ***0chroma pyramidale*** (Cav. ex Lam.) Urban, was introduced in 1961 and established at Keravat in East New Britain. This species is now considered synonymous with 0. lagopus (Whitemore and Hartshorn, 1969). In New Britain, two distinct entities of Balsa can be recognised by their differences in tree form and leaf characteristics. One of these is believed to be a descendant of the 1961 introduction.

Balsa has been distributed widely throughout a number of provinces in PNG in extension trials. The most important distribution is in the Keravat region, on the Gazelle Peninsula of East New Britain, where milling and export of Balsa wood has developed into an important industry. In 1992, the Balsa resources were providing material for three private company mills. Three mills are still operating today and there is considerable interest in other provinces to establish a Balsa wood industry.

The original silvicultural techniques for Balsa in PNG (White and Cameron, 1965) were altered in 1977 to cater for the requirements of the industry. These techniques have not been strictly adhered to by the industry and as a result, Balsa was commonly planted at close spacing of 2 x 2 metres with clear falling at around 26 to 36 months became common place instead of following the forestry silviculture techniques thinning schedule for Balsa.

A spacing trial, established at Keravat in 1981, highlighted the importance of initial close spacing for maximising log length production; it also highlighted the need for further short termed thinning trials to determine the maximum limit of spacing and thinning to maximise growth and yield. Work in this field was continued jointly by forestry and the Lowland Agricultural Experimental Station (now called NARI) from 1993 to September 1994 when the trial was badly damaged by the fall out from the Volcanic eruption to be of further value.

Following the results of the earliest forestry spacing trial, the East New Britain Balsa Industry Strengthening Project, under the National Forest Service, promoted the use of 2.5 and 3.0m square planting spacing rather than closer spacing of 2 x 2m square. A two tiered commercial thinning schedule applied over a five to six year period is also being recommended for large scale plantations. Both these establishment and management schedules are gradually being accepted for general use.

The industry's past policy on logging the best trees first in the plantations caused considerable concern for the future of the genetic resources in the region and by 1982 a tree improvement selection program was established. This work was extended in 1992 with the selection of some 100 candidate seed trees and the establishment of a small seedlings seed orchard.

Today, Balsa has become increasingly important to the village economy as a cash crop supplement to cocoa, copra and coffee. Because of its rapid growth and the early financial return it gives to the local grower, the rural community prefer to grow Balsa rather than invest in long term species such as Teak. With a sharp downturn in the copra industry, Forestry and Agriculture extension services are actively encouraging the establishment of village Balsa wood plots as an alternative source of income in a move towards rural crops diversification.

2.0 NOTES ON TAXONOMY AND NOMENCLATURE

Balsa

Family: ***Bombacaceae***

Species: ***Ochroma lagopus*** **Swartz., Prodr. 98.1788**
Synonym: ***Ochroma pyramidale*** **(Cav. Ex Lam.) Urb. In Repert. Spec. Nov. Regni. Veg. Beih. 5:123.1920.**
Basionym: ***Bombax pyramidale*** **(Cav. Ex Lam.) Encyclopedic Methodique, Botanique 2: 552.1788**

Other common names: Balsa (Central and South America), Corcho (Mexico), Gantillo (Nicaragua), Enea, Pung (Costa Rica), Lana (Panama), Pau de balsa (Brazil), Palo de balsa (Peru), Tami (Bolivia).

There are several schools of thought regarding the botanical nomenclature, the most prevalent being that the species in PNG should be called ***Ochroma pyramidale.*** The most common name used in PNG is ***Ochroma lagopus*** and rather than cause confusion, this name is applied in the manual.

A number of other names have been noted in literature and some have been applied to ***Ochroma lagopus.*** These are: ***O. bicolor, O. boliviana, O. grandiflora*** and ***O. tomentosa.***

There appears to be two entities introduced into PNG. The first, with the best commercial characteristics is reputed to be from Ecuador and the second is reputed to be of Columbian origin. The latter has smaller leaves and it is tomentose on the underside of the leaf and on the petioles. This one may have come through Indonesia from Kota Nica where it has been referred to as ***Ochroma bicolor*** and ***O. tomentosa.*** It seems likely that this is synonymous with ***O. pyramidale*** which is thought to be the accession that has performed poorly here in PNG, in terms of growth and form as well as branch habit.

2.1 BOTANICAL FEATURES

Habit and bole: Balsa is a tree from 20 to 30m tall and of 50 to 200cm in diameter or more. On best sites, some trees have attained a height of 23m and 50cm diameter in 30 months. A slight buttress starts to develop around 6 years and increases in size with age.

The tree is monoecious and the bark is grey-brown, more or less smooth without fissures and does not flake or peel. The inner bark is usually cream in colour in young trees.

Branches and foliage: The young tree produce a long internode after each set of branches. The branches are usually produced in sets of three, of which one will take over as the ascending axis. The internode length usually become progressively shorter as the tree becomes taller.

Some entities produce branchlets on the bole and on the internode lengths at an early age and in some cases these may persist for some time. Others produce bole without branchlets. The three lobed to heart-shaped leaves of young trees are usually very large and over 200cm across in optimum growing conditions. The petioles of these are around 100cm long. These are borne on the trunks of young trees, short lived and progressively shed. The leaves and petioles become progressively smaller with age.

Flowers: Flowers are towards the end of the branches, single or in twos or threes, large, tubular, bell or trumpet shaped with a brownish, cream to white corolla, around 13 - 15cm long by 8 - 10cm wide (Womersly, 1963). The anthers are fused to a spadix or tube like organ wrapped around the style and stigma. Both protrude slightly above the perianth of the corolla (Plate 1 A - B).

Pollination: Balsa is bat pollinated (Mac Millan, 1991), and also pollinated by insects.

Fruit: The fruit is slender ten angled capsule or pod up to 30cm long with very small ovoid seed embedded in a dense mass of silky hairs or kapok. (Plate 1 C-D). The seeds are wind dispersed.

Phenology: The tree grows almost continuously throughout the year and flowers and seeds throughout the year in PNG. Regional variation has been noted.

2.2 NATURAL DISTRIBUTION

Balsa is widely distributed in the tropical Americas; throughout the West Indies, and from Southern Mexico, through Central America and into Venezuela, Colombia, Brazil, Ecuador, Peru and Bolivia. It is usually found at lower elevations, lowland soils and along streams and colonies cut over forest and clearings.

2.3 ENVIRONMENTAL AMPLITUDE

Climate: Average rainfalls between 1500 to 2000mm per annum with average temperatures of 25 to 29 degrees Centigrade with short dry seasons.
Soils: Balsa is found on fertile, well drained hill and lowland soils.

Plate 1 (A)

Plate 1 (B)

Plate 1 (C)

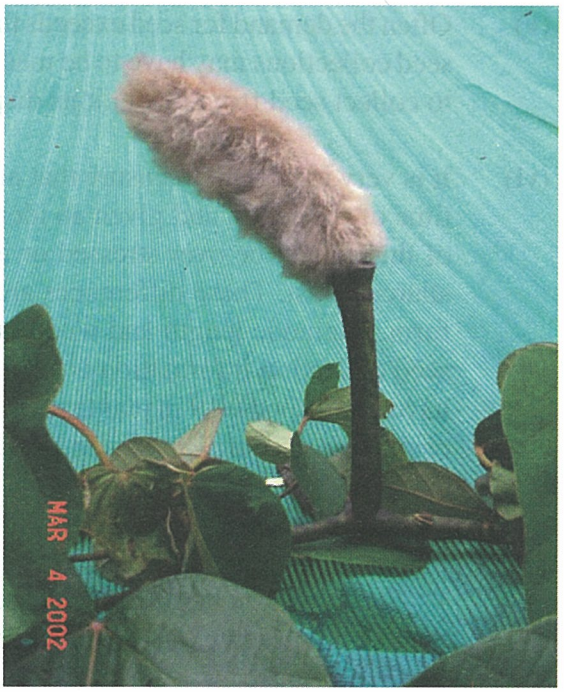

Plate 1 (D)

Plate 1 (A) Open flower and young flower bud. ***(style and anthers project above the flower).*** **Plate 1 (B) Top view of open flower showing style and anthers. Plate 1 (C) Green pods** ***(Not ready for collection).*** **Plate 1 (D) Pod ripe with kapok emerging** ***(This is ready for collecting and can fall to the ground at this stage).***

3.0 SEED COLLECTION AND NURSERY

3.1.0 SEED COLLECTION

The importance of using Balsa seed from good seed sources such as seed trees and seed orchards has been clearly demonstrated over a five year period by the ITTO Balsa Industry Strengthening Project in Phase I and II and the use of good seed from documented seed sources has become a standard practice recommended to the industry.

3.1.1 Seed Sources

(i) Seed has been traditionally collected from plantations at Keravat. Mostly, these have been ground collections.

(ii) Where possible, seed should be collected from plantation seed trees selected for good stem form and vigour.

(iii) The first generation of seedlings seed orchards are producing seed and seed from such sources should be used to establish Balsa plantations.

(iv) Balsa seed can be obtained through the National Forestry Office at Keravat.

(v) Often the demand for seed exceeds the supply from the above sources. In this situation, seed collections may have to be made in village plantations. Care should be exercised to collect seed from plantations displaying good form and vigour.

(vi) It is very important to ensure that all seed collections are recorded in the field at the time of collection and given an identity by a number or by a name. The importance of this cannot be over stressed or ignored, as significant differences between seed sources exist. These differences are of economic importance e.g growth rate, stem form, intemode length and wood quality. The records of the seed source and other seed collection information is used to identify the source of good seed batches that have performed well in plantations, so further seed collections can be made from the original seed source and the information can be used for tree improvement purposes.

The information required is as follows:

- Seed tree number (or in the case of bulk seed collections) the number of seed trees represented in the collection.
- Location of the seed trees.
- Date of collection and name of collectors.
- Type of collection; from ground or direct from the tree.

3.1.2 Seed Tree Selection

(i) Aims

Seed tree selection aims to:-

- Produce fast growing plantations with improved wood qualities.
- Increase wood volume production per hectare and reduce crop rotation time by maintaining and improving vigour, stem straightness, increasing merchantable bole length and reducing or eliminating defects.
- Increase initial planting spacing to reduce the need for un-merchantable thinning.
- Conserve and maintain the best of the breeding material in perpetuity.

(ii) Selection criteria

Four main traits are considered when selecting Balsa seed trees. These are: vigour, stem form, minimum buttressing and the length of the log produced by the tree. Selection is best done in even aged plantations as this enables the candidate seed tree's performance to be compared and quantified with that of adjacent trees of the same age.

Seed tree selection in plantations should start as early as two years from establishment and generally no later than age four years so defects can be detected before they are occluded. Dominance is usually established by the age two years and acceptable bole length by the age three years. The latter often continues to develop at least up to age six but more defects are likely to develop as crown branches become larger.

(a) Selection for Vigour

Trees that are dominant and have greater diameter and height than their nearest neighbours within a 10 metres radius can be considered for selection providing they meet the other requirement described below. Dominant trees should have greater than 10% volume advantage over the average volume of the largest 5 comparison trees.

(b) Selection for Stem Form

Stem form is important when it comes to maximising recovery from a tree. The Balsa mills are presently accepting logs of 1.3 and 2.4m lengths and rejecting sections that have branches or branch stubs. This means that there will be logs of odd lengths, with the stub sections that will only be accepted if the mill can process them. At present, logs 90cm can be accepted, but anything shorter will be rejected. Breeding Balsa trees from mother trees with long branch free boles and longer intemodes to increase recovery is an important objective of the tree improvement program.

Trees that have perfectly straight clear boles or with stems that have hard-to-define kinks or sweeps may qualify for selection providing they meet all other requirements. The bole of the tree should be cylindrical, with no fluting and with little or no evidence of root flanges developing at the base up. The stem should be free of heavy branch stubs or large occlusion scars.

Short stems (less than 4 metres), terminating in 2 to 3 large branches should not be considered. In most cases, one of the three branches will continue to grow as part of the main trunk and usually such trees will produced a bole with a succession of easily detected kinks and sweeps and large branch stub occlusion scars.

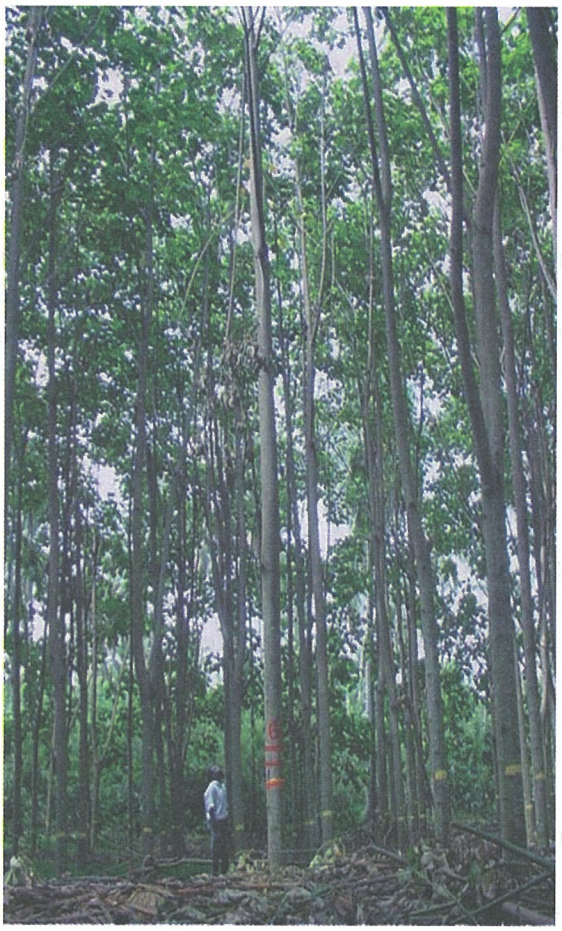

Plate 2 (A)

Plate 2 (B)

Plate 2 (A) Balsa seed trees selected for vigour, age 4 years. *Note good internode length.*
Plate 2 (B) Balsa seed tree selected for vigour and good stem form.

(c) Selection for Log length

Although the length of clear bole in Balsa can be improved considerably by the use of shorter planting distances between trees as has been demonstrated in field trials, there is evidence that bole length in plantation trees is further improved by using seedlings produced from trees selected for long clear, defect free boles and intemodes (Plate 2(A)).

Commercial Balsa length is determined by permanent crown break, (created by a distinct fork), by the first set of permanent, heavy branches or by excessively large bumps, bends or branch stubs.

The minimum length for a straight defect free bole should be 12 metres to crown break, the first set of permanent branches or defects (Plate 2(B)).

(d) Selection for Health

Trees with evidence of red heart (dark red sap exudation from cracks in the bark) or insect attack in the stem are not to be considered for seed tree selection and trees showing any sign of disease or ill health are not to be considered.

(iii) Assessment and Recording

(a) Assessment Forms

A point score system is used to evaluate candidate seed trees and this is recommended for use by Balsa plantation owners. A seed tree selection form, listing top scores for each important character is provided in Appendix 2.

(b) The Point Score System

The scores for each character assessed are provided on the selection form, and are applied as follows:

Vigour

This is based on the volume advantage the candidate seed tree over the volume of the next five largest trees within 10 metres radius of the candidate. Scores are provided for different percentage of volume advantage under the column for Vigour (Compare candidate seed tree with adjacent trees in Plate 2 (A)).

The volume advantage of the candidate seed tree should be based on the volume of the standing merchantable log in each of the five comparison trees. Scores are entered in the blank column provided on the assessment sheet (Appendix 2).

Total height of the trees, diameter at breast height (DBHOB) and log length details for the comparison trees are to be entered at the bottom of the form and the top of the form for the candidate seed tree.

Log volume is based on over bark measure and calculated using the National Forest Authority's Balsa volume tables. These are based on calculations using the diameters of the top of the log, mid-log, at breast height and length of log.

Apical Dominance

A tree has apical dominance if the ascending axis (main stem) is straight and still elongating without forking, thus capable of producing more log length.

Crown Dominance

Dominant crowns are defined as those which are well above the crowns of the adjacent tree while co-dominant crowns will be equal in height to adjacent trees. It is possible from age six years onwards for trees with volume advantage to still have co-dominant crowns.

Merchantable Log Length

This is more or less self explanatory on the selection form in Appendix 2. However, it should be noted that trees which grow with a long stem to the first set of branches, which is followed by several more long internodes of similar length, are very likely to produce seedlings with similar features. Such trees and especially vigorous trees will give more recovery of wood and a higher earlier yield.

When selecting trees, the assessor should keep in mind that the sawmills cut billets of 1.3 and 2.4 m lengths. Therefore, every potential log in a candidate seed tree should be examined on the basis of how many merchantable clear wood billets of 1.3 and 2.4 m lengths can be obtained from the candidate seed tree. If logs are of irregular length due to the tree's growth and branching pattern, then excessive waste will occur when that tree is harvested and recovery will be reduced. (Refer further 3.1.2 (c) above on this subject).

Kinks and Sweeps

Kinks in Balsa trees are usually slight and usually there is some evidence of external influence such as vines or a tree that may have fallen against the candidate. Wind also can influence the production of kinks and sweeps. It should also be kept in mind that trees that are not wind firm may not be good candidate seed trees.

The point scores can be adjusted according to the number of kinks or sweeps present i.e. if the tree had these faults in both sections above the 5 and 10 metre sections, points can be deducted from the scores allocated for each. Thus, top scores of 5 points can be reduced depending on the severity of the defect.

Knots and Nodes

These are caused by the occlusion of stubs of moderate to large branches and where observed, points should be deducted according to the severity of the defect. Scores 15 to 5 can be altered to 10, 2 if the assessor sees fit to do so. Trees with numerous persistent vigorous branches on the lower bole should not be selected as seed tree candidates.

Where such trees have fine branches on the bole that are being shed early, and shedding without leaving large knots or abscission scars, these trees can be considered for selection as seed trees providing they have outstanding form and vigour.

It should be noted that persistent branching is not necessarily eliminated by close spacing. Progeny trials at a spacing of 2.0 x 2.5m have demonstrated that branching can persist under competition for sufficient time to render the lower bole of a tree useless for milling or to reduce recovery due to the inclusion of large and long branch stubs in the wood. This problem is clearly genetically controlled.

(c) Identification of Seed Trees

A numbering system is used to identify each tree and its location details should be recorded accompanied by a location map. The trees are marked with red paint rings and with the number painted on the tree. An identity tag wired into the tree is useful as the paint marks can fade with age and tree growth.

- Trees with single red rings and no number are slightly better than average or have some useful characteristics but are not good enough for A, B or C grade selection status. These are to be used for general seed collections.

- Trees with two red rings, and a number with the letter "C" at the end of the number are considered "C" grade seed trees and have scored around 50 - 60% of the total marks allocated for high grade seed trees.

- Trees with three red rings and a number and letters "ST" are considered "A" and "B" grade seed trees in the past. Since progeny demonstration plantings have indicated little difference in the performance of these grades of seed trees, they are generally treated as one grade.

3.1.3 Estimation of Fruit/Pod and Seed Crop

(i) Seed Yield

- The number of seeds per pod range from 400 to 600.
- There are between 150-170,000 seed per kg.

(ii) Forecast of seed crop

Seeds are produced in large elongated cylindrical pods. Generally, the assessment of the number of pods on a tree is a difficult task. Often at the best, the assessor can do is to note that the pods are present and that there appear to be either plenty or few.

Approximate estimates can be made by counting the visible number of pods from one side of the tree and multiplying by that number by three. To estimate the number of seeds that may be available, the figure obtained from the first calculation should be multiplied by 400. Estimation of seed weights can be done by dividing the number of seed by 160,000.

Seed viability is generally very good with fresh seed and the seed stored in cool room conditions for at least up to two years. Seed extracted from partly ripe pods can give poor germination. Germination estimates should be based on a 60-80% viability rating to be safe.

Pod bearing seed trees should be identified during April and May prior to the pods ripening so as to reduce operational time in seed collection.

3.1.4 Seed Collection

(i) Time

Seed collection is usually carried out from June to early November. Some collection may be possible as early as April.

(ii) Methods

Pods are collected from trees by using a slingshot to lob a line over the pod bearing branches to pull the branches down, or ripe pods may be collected when they fall to the ground, usually after rain and wind.

Climbing is sometimes done in the seed orchards to collect pods but this can be dangerous as the trees have smooth bark that can be difficult to grip. It is not a recommended practice.

Tree climbing ladders may be used in some situations but big seed trees may be too large and these may have to be permanently spiked with metal rods for footholds to assist the climber to reach the crown. This should only be used for large seed trees and the spikes have to be pulled outwards periodically to prevent the tree trunk from growing over them.

The seed collection team are to make sure that the bags holding the ripening seed pods are labelled to identify the seed source and contain the relevant details of the collection, i.e. the number of seed trees represented in bulk collections or the seed trees identity, the location of the trees and the date of collection and name of the collectors.

3.1.5 Seed Extraction

(i) Methods

The small seed is enmeshed in a fine 'Kapok' and this is removed by hand from the pod when it splits as it affects the viability of the seed (Plate 3). To extract the seed, the 'Kapok" is placed in buckets and flailed with a home made broom made from coconut leaf ribs.

(ii) Seed Weight Requirements

There are approximately 15000 - 17000 seed per 100 gms and at 60% viability, in rounded figures, approximately 180 gms would be required to establish 10 hectares of plantation planted at 2.5 x 2.5m square or 150 gms for the same area planted at 3.0 x 3.0m square. For both spacings, it is advisable to sow 200 gms so as to compensate for seedling losses and loss in seed viability.

Plate 3
Extraction of seed bearing Kapok from Balsa pods prior to flailing to remove seed from Kapok

3.1.6 Seed Storage

The seed is stored in an airtight container in a refrigerator at + 3 degree centigrade.

Seed must be labelled. The record should show the seed source, date of collection and weight. A label must be kept inside the container as well as on the outside.

3.2.0 NURSERY

3.2.1 Facilities

(i) Basic requirements

A Balsa nursery should contain a building that has an office and equipment storage space. Attached to this should be a section for seed germination and tubing. A soil storage and processing shed is required to store tubing soil in fairly dry conditions.

A minimum of 0.5 hectare should be kept adjacent to the buildings as the commercial nursery stand out bed area. This area will also contain space for seedling germination beds.

The nursery should be provided with a reticulated water supply fed from catchment tanks. Water drawn from drains is totally undesirable, particularly where water may stagnate. Bacterial infections often start with the use of water in seedling trays from this source and serious seedling losses will occur.

(ii) Germination and tubing sheds

These can be placed under one roof or kept in separate sheds. The size, shape and design depends on the availability of land, size of the production operation and the costs of material and handling.

The Keravat operation incorporates germination, tubing and transplanting of seedlings to the tube, under the one roof. A portion of these operation is shown in Plate 4 below. Seed germination trays can be seen on the left.

In all cases, the germination tables are waist high and are sufficiently wide for the nursery man to reach the back trays placed on the tables. The table tops can be made of wooden slats or arc-mesh wire to allow drainage. The tables should not be tiered, as drips from the top layers will damage the germinating seed on trays located on the bottom tiers.

Plate 4
Tubing shed operations
Background: tubes being filled with soil for pricking out seedlings
Foreground(L-R): tubes with young seedlings and tubes with seedlings ready for transfer to stand out beds.

It is important to note that the germination area must be protected from rain. The germination trays are susceptible to attack by rodents and snails and should be covered until germination has taken place.

(iii) Germination beds

The ITTO Balsa project successfully experimented with outdoor germination beds in 1998 but did not adopt this system until the year 2001 to overcome pathogens problems experienced with seedling production in the standard seedling germination trays.

Germination beds can be temporary or permanent, but should be placed away from any source of overhead shade. Recommended bed size for commercial seedling production is around 1.3 x 15m, with the top of the sides of the beds approximately 15cm above ground level. Soil and grass should be excavated before the sides of the beds are put in place (Plate 5).

Plate 5

A temporary Balsa seed germination bed showing sarlon shade cloth removed to expose germinating seedlings which are ready to lift to transfer to the tubes of soil in the nursery shed. This commercial production system has so far proved free of pathogens problems and uses waste soil from the tubing soil preparation system. The centre board allows the nursery man to move down the centre of this bed to weed and to lift the seedlings for tubing.

It is recommended that the beds be shaded with "sarlon" shade cloth at approximately 60-70% shade.

This should be placed on supports to keep the cloth around 10cm above the surface of the soil. Bamboo slats or wooden slats can be used as a substitute for shade. Where the beds are wider than 1.3m, a broad board walk way should be established down the centre of the bed to allow the nursery man to move down the centre of the bed to weed and to sow and lift seedlings.

Protection of the seed and the seedlings should be established at the same time as the bed construction is completed and ready for sowing. Snail and rat baits should be in place before sowing the beds.

(iv) Stand out beds

Stand out beds illustrated in Plate 6 (A) and (B), consist of a cement base 15m long and 1.3 to 1.5cm wide and around 15cm above ground level. The beds are positioned in a north/south direction to ensure all seedlings receive even light.

The tubed seedlings are stood out on the cement, supported by chain wire mesh or arc mesh stretched out on wooden support frames.

The chain wire fencing mesh comes in roles of around 15 x 1.3m and in different size meshes. The mesh should be large enough to permit the plastic planting tube to be slipped into the mesh gap without difficulty and to keep the tube upright.

The same applies to the arc mesh which comes in sheets. Some people prefer arc mesh for cocoa seed drying trays and the sheets are some times stolen from the nurseries, so the chain mesh fencing wire has a small advantage over the arc mesh wire.

The shade cloth placed over the bed can be supported by wooden posts and frames, however, these often have a short life of a few years and require constant replacement. In their place, the ITTO project introduced the use of galvanised iron pipe supports cemented into the ground and capped with replaceable wooden supports and tie wire runners connecting each metal post so as to support the sides of the sarlon shade cloth (Plates 7 and 8).

The metal support pipes may be 2 to 5cm in diameter depending on availability. However, height is important to ensure the seedlings get adequate shade and not too much side light. Each bed has around 4 - 5 pairs of pipe posts. On one side of the beds, the pipes are 110cm above the ground and on the opposite side of the bed, they are around 115cm above the ground so as to create a slope towards the east.

Plate 6 (A)

Plate 6 (B)

Plate 6 (A) General view of the Keravat Forestry ITTO Balsa Project Balsa nursery under sarlen shade. Plate 6 (B) Stand out bed with shade cloth removed to condition seedlings to direct sun light and to harden them up for planting in the field. *(note cement base, the wooden frames supporting the wire mesh and the support pipes to hold up the shade cloth. The support wires are not visible).*

(v) Shade requirements

Overhead shade and protection from prevailing winds and from rain is required for seed germination and tubing. In most cases, an open shed with benches serves this purpose.

Stand out beds require shade to protect the young seedlings when they are stood out in the beds, as they will not be hardened to withstand strong sun and can be burnt and killed. The shade also prevents the soil in the tubes from drying out quickly after watering.

"Sarlon" shade cloth of approximately 60 to 70% is used to shade seedlings in the stand out beds and this is removed to harden the seedlings 1 to 2 weeks before planting. In a number of instances, nursery staff have released seedlings for planting before they have been hardened off without any serious after effects on plant health and growth (Plates 7 and 8).

(vi) Water supply

- Germination trays are best placed in shallow trays to soak up water rather than to water overhead as this method can damage germinating seed. Care should be exercised not to over water as this leads to fungal attack.
- Seedlings freshly transplanted into tubes should be watered once or twice a day.
- Seedlings in stand out beds should be watered daily ensuring that the edge rows are well watered, as these dry out quickly.

3.2.2 Nursery Techniques

(i) Soils

Sandy loam with good binding characteristics is adequate as a medium for raising seedlings. Soil sterilisation is not always required. However, if infection occurs and sterilisation is required, then heat sterilisation for 1 hour is recommended for the soil before the seed are sown.

Tubing soils should be a friable loam which can be held together by the seedling roots at planting with a minimum of core fracturing. The latter can cause the exposure of the seedling's root system at planting when the tube is removed, resulting in desiccation and death.

Soils to be used for tubing or seed tray preparation for seed sowing has to be passed through a sieve. The soil sieve is a simple construction consisting of a square wooden frame around 2.5 x 3.0m square with coffee wire stretched across and fastened to the frame with "u" nails.

(ii) Sowing

(a) The seeds are sown in seed boxes, trays or in large beds by either broadcast sowing or in closely spaced shallow drills. The seed should be lightly covered with sand. Watering should be applied from below, by standing the trays for few minutes in shallow water. This should be done once every one or two days.

- Seed weight requirements for 1 tray is 20 - 25gms. The most convenient scale is 1 match box full of seed to 1 tray. A match box holds between 20 - 25gms depending on seed size.

Seed sown in open beds will have to be watered overhead and care should be taken to ensure that the water is applied lightly so as not to remove the seed from the cover of soil. All trays must be kept under shelter in a shed and provided with an overhead cover or lid to prevent rats and mice from eating the seed. Usually an empty seed tray is used for this, weighted down to prevent it from falling off.

The open bed technique requires a low cover of shade cloth (50 - 60% shade). This method is recommended where commercial seedling production is affected by persistent fungal and bacterial attack.

Seed weight requirements for beds depend on bed size. As a guide the following:

- Beds 3 - 4 x .15 - 2.0m broadcast, sow 200gms.
- Beds 13m x 1.3m, sow 250gms.
- 1 coca cola bottle holds 260gms and can be used to scale the seed for sowing.
- 1 small coffee bottle holds approximately 100gms.

(b) All seed trays or beds sown with Balsa seed must be labelled with the batch number of the seed and date of sowing. The identity of the seedlings and destination must be recorded when the seed is distributed so as poor and good quality seed sources can be identified in the field.

(c) Once sown, the sowing trays should be kept under a roof protected from heavy rains and direct sunlight.

(d) Balsa seed should be sown 4 months before the normal planting time. This provides ample time to carry out further sowing up to 2 months before planting if the germination of the first sowing is poor, or if pre or post tubing losses are excessively high.

(iii) The Bush Germination Technique (Plates 7 A and B)

Insufficient planting stock due to seed shortage or severe losses of germinating seed in the nursery can be supplemented with the use of seedlings transplanted to the main nursery from bush germination beds, cleared and cultivated under and around seed trees or in seed gardens.

Plate 7 (A)

Plate 7 (B)

Plate 7(A) Seedlings germinating in a bush nursery and ready for transplanting in tubes in the Balsa nursery. Plate 7(B) Collecting seedlings from a bush nursery.

This method has been extremely successful in locations where good seed sources have been established for a long time. Some contamination with poor quality stock is possible, but generally the quality of stock produced from bush germination beds, under seed trees and in seed gardens, has proven to be of acceptable quality and field performance.

Seedlings should be lifted from the bush beds with care so as not to break the tap and lateral roots. The operation should be carved out early in the morning before it becomes hot and sunny. All seedlings should be stored in a cool moist container for transporting to the nursery tubing shed without desiccation problems. A bucket or watering can is adequate for this (Plate 7(B)).

All such collections should be given batch numbers and documented the same as for seed batches.

(iv) Tubing Soil

(a) Tubes

There are different size planting tubes available on the market and it is important that the most suitable and economical size be used. Tubes which are large means too much soil will be used and fewer seedlings can be transported at once to the planting site.

The standard type of planting tube used for Balsa seedlings is a black polythene tube 2 x 8 inches or around 5 x 20cm (flat), with perforations.

These can be obtained from most agriculture supplies outlets in PNG, and can be purchased in lots of 100 bags or in bulk packages of 10,000 tubes.

(b) Method

This is a simple process which requires sieved soil, a home made funnel with a mouth that will fit into the opening of the tube. The top of the funnel is wide to form a scoop.

The soil is shovelled up with the use of the scoop and dropped into the tube where it is fumed down by tapping with a flat paddle. The soil should not be loose in the tube and the tube of soil should be able to lie on its side without the soil falling out.

(c) Productivity

The maximum productivity recorded is 800 tubes per man/day.
The average productivity is 500 tubes per man/day.

(v) Pricking out Seedlings (Figure 1)

(a) Germination should commence around two days after sowing and it should be completed within 14 days of sowing. The seedlings should be tubed when they are 2 - 4cm high.

PRICKING OUT TECHNIQUE

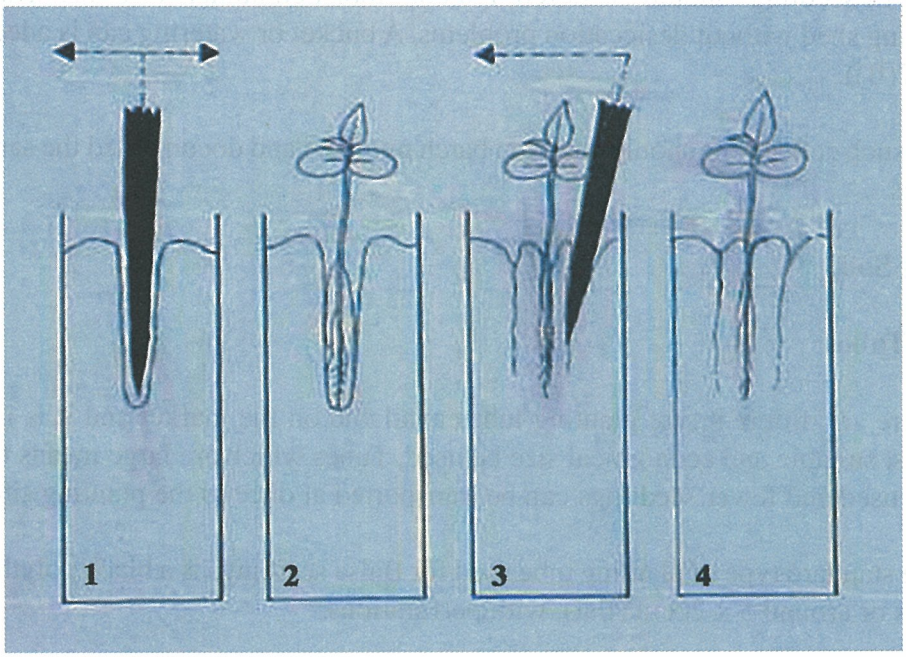

Figure 1 – Method of tubing or pricking out Balsa seedling into plastic planting tubes of soil.

Stage 1: Pointed stick used to make a planting hole. Pointers and dotted lines indicate movement of stick alternately right to left to enlarge hole.
Stage 2: Seedling inserted in enlarged hole to depth just above top set of roots. Avoid bending roots as this can cause the root to twist and grow around itself and strangle itself.
Stage 3: Pointed stick used on both sides of seedling to close the hole gently and firmly around the seedling roots.
Stage 4: Roots now closed in the soil. No space or air pockets left around the roots which can kill the roots and the seedling. Tubed seedlings at this stage must be watered every day, and the seedlings must remain for around 4 to 5 days in the tubing shed under shade before transferring to shaded beds outside.

(b) Tubing should be completed before the new leaves develop about the cotyledons. Considerable care must be exercised when tubing, as the stems of the seedlings are soft and the roots are easily broken.

(c) Tubed seedlings are to be left under the shade of the shed for at least 4-5 days after pricking out. During this time they receive daily watering and on application of fertiliser before removal to the stand out beds.

(d) All seedling batches tubed should be labelled and this label is to follow the seedlings to the stand out beds.

(e) Productivity: the best production is 2,000 per man/day. This can be done by an experienced worker. Average productivity is 5-600 tubes per man/day.

(vi) Fertilising in nursery

- The commercial garden all purpose soluble fertiliser called THRIVE has proved to be the most effective fertiliser used to promote good healthy seedling growth in Balsa. The NPK ratio is 27-5.5-9 and the fertiliser also contains the elements Magnesium, Copper, Zinc, Boron, Manganese, Iron and Molybdenum.
- The application mixture is one level measuring spoon or 8 gms of fertiliser in 4.5 litres of water mixed in a back pack spray or in a watering can.
- The mixture is applied to the seedlings as an overhead spray.
- One application is applied to seedlings in the tubing shed at age 3 or 5 days.
- Applications of the fertiliser mixture are made to seedlings on a fortnightly basis in the stand out beds and on a weekly basis if the area has been subjected to heavy rain falls.
- The recommended mixture can be adjusted to half strength if seen required but it should not be increased beyond that recommended above.

(vii) Stand out Bed Phases

(a) The freshly tubed seedlings should remain under cover in the nursery shed for one week to recover from transplanting shock.

(b) After this, they are placed in the stand out beds under full shade. The shade is progressively removed to full sunlight by the end of the second or third week.

(c) The seedlings usually take up to 16 weeks to reach a planting size of 10 - 13 cm. Applications of soluble fertilisers as recommended above may produce seedlings ready for planting out within 8 weeks.

(d) All batches of seedlings must be labelled and identified by batch numbers in the stand out beds.

(viii) Watering

Seedlings are to be watered at least twice a day after pricking out into the tubes and after they are transferred to the stand out beds.

(ix) Nursery Diseases

(a) Outbreaks of fungal infestation resulting in losses of seedlings in the seed trays can be prevented by applying THIRAM fungicidal powder to the seed prior to sowing. Rates to apply are: 1% of Thiuram against seed weight, i.e; 1 table spoon to 400gms of seed.

(b) Soil can also be treated prior to sowing. CARBAM can be used as a soil fumigant. Recommended application is as follows: Apply 3ml to each 30cm distance of soil to 2 weeks prior to sowing seed. The soil should be dug over 10 - 14 days before sowing to release any residual gas from the soil.

(c) Seedlings infected in the trays can be spread with a solution of MANZEB. Recommended application is as follows: Use 10gms (4 table spoons) per 5 litres of water. Pre-mix a small volume of water to form a thin slurry before adding the remaining volume of water. Keep well stirred.

(d) Spray at 7 - 10 day intervals or more frequently during wet weather. The foliage of the seedlings should be covered with the spray to achieve good control. The spray should be applied before the infection becomes well established.

(x) Pest Control

(a) Rats and Mice: Commercial baits are readily available from stores and all brands are considered effective if applied as recommended. Baits placed in the nursery are best put in bamboo tubes or buckets laying on their side to prevent wet weather from destroying the baits.

(b) Snails: The giant snail is still a common pest in many parts of the country but can be easily controlled with the use of snail baits available at stores selling agricultural supplies. A bait with some resistance to open wet conditions is recommended, otherwise the baits should be placed in sheltered areas such as under logs and large leaves.

(c) Insects: Nursery seedlings can be affected by army worm, caterpillars and grasshoppers. Mild systemic insecticides used for vegetables can be applied.

(xi) Weed Control

(a) Around beds

Weeding is done both by hand and with the use of chemical sprays. Beds should be kept free of weeds and grasses and this helps to some extent in the control of insects. As a control treatment, Gramoxone or Glyphosate weedicides can be applied by spraying using a knapsack spray. Applications should be made with care as the spray can damage or kill the seedlings (Plate 8).

Plate 8
Seedlings killed by drift spray from carelessly applied weedicide, (In this case Glyphosate chemical spray used to kill grass and weeds around stand out beds).

The best time to apply these chemical sprays is in the morning when there is no wind or breeze. Applications are best made when there are no seedlings in the bed.

Mixing rates are as follows:

Gramoxone: Mix 100 mls to 10 litres of water
Glyphosate: Mix 100 mls to 10.5 litres of water

The use of a graduated measuring cup is recommended and gloves should be used as a safety precaution when measuring out the chemical and mixing. The mixtures are to be applied using a knapsack spray pump. Protective clothing and foot wear must be worn. Read the safety precautions on the label of the canister containing the chemical and follow these instructions.

(b) Seedlings in Tubes

All weeding of seedlings shall be done by hand. Do not apply any chemicals as the seedlings will die.

4.0 PLANTATION ESTABLISHMENT

4.1.0 SITE PREPARATION

4.1.1 Site Selection

Balsa is site demanding and requires careful selection of site.

(i) The site must be well drained and rich in nutrients.

(ii) The sites should not be swampy or be temporarily wet as trees will suffer root damage, lose their ability to stand up to wind and they will fall over or blow over (see Plates 9 and 10 below).

(iii) Soils should not be shallow. Root penetration should be possible to at least 1 metre.

(iv) Grassy sites should not be considered for Balsa planting.

(v) The site should not be exposed to strong winds.

(vi) The area must have a good annual rainfall between 1500 to 2000 mm per year with average temperatures of 25 - 29 degree. Balsa should not be subjected to long periods of drought stress.

Plate 9: Severe wind throw in orchard due to poor root system on wet site
(Note, wind firm seed tree at back left)

Plate 10: Tree blown over on poorly drained site in orchard at Keravat.
(Note, wind firm seed tree to left)

4.1.2 Clearing and Preparation

(i) Balsa is a pioneer species and grows best in open conditions in direct sunlight. The planting site must be cleared of standing trees and bushes by felling and burning. This must be completed before the wet season to minimise grass and weed competition at planting.

(ii) Planting lines should be demarcated after the clearing and burning operations are completed.

(iii) Initial close spacing has been used in the past to produce good stem form and to reduce stem defects. The standard spacing for close planting Balsa is 2.1 metres between rows and between trees i.e 2,200 sph. However, plant spacing of 2 metres are also used. This results in more seedlings being planted i.e 2,500 sph. Close spacing is more wasteful and less economical to the small holder Balsa grower when he has to pay for his seedlings.

(iv) Where the plantation owner may be forced to plant at a wider spacing because of insufficient stock, his planting spacing should not exceed 3.0 metres i.e 1,110 sph.

(v) Some growers prefer to use triangular spacing because they are used to using this type of planting pattern for establishing cocoa. Should this be the case, then the 3.0 x 3. 0 m spacing is recommended.

4.2.0 PLANTING AND TENDING

When establishing blocks or plantations, it is advisable to keep a record of the cost of establishment, management and production to determine profit and losses in production and to keep a record of the identity of the batches and their planting location in the blocks or plantations, as some batches may prove to be useful seed sources for the grower and the industry. These records are sometimes referred to as a plantation history.

4.2.1 Size of Planting Stock

(i) The minimum size of planting stock is 10 cm and the maximum should be 15 cm. Sturdier stock can be used but these can be unstable due to root binding.

(ii) Stock should be graded for size when removed to the stand out beds. Indiscriminate mixing of trees of different height grades at planting should be avoided.

4.2.2 Method of Planting

(i) Planting should be effected as soon as possible after clearing and burning.

(ii) The tubed seedlings should be well watered before transfer to the planting site.

(iii) The plastic tube of the container must be completely removed at planting.

(iv) The past practice of slitting the side of the tube and planting the tube with the seedling should be avoided as this does not allow the seedling to produce a good lateral root system to take full advantage of the surrounding site at establishment. This practise may contribute to slow establishment growth and an unstable tree.

(v) The core of soil around the roots must be kept from breaking up and placed carefully in the hole and filled in and the soil firmed by packing to remove air pockets. The planted tree should not be loose in the filled-in hole.

4.2.3 Refilling

(i) Refilling is recommended only if the survival is less than 80% and if the spatial arrangement of the survivors is such that large gaps are left in the plantation.

(ii) Refilling should be done as early as possible for example no later than 2 weeks after the first planting. Otherwise, the survivors of the first batch planted will dominate and suppress the refill plants.

4.2.4 Fertiliser Applications

To date, it has not been standard practice to apply fertilisers to Balsa seedlings at the time of establishment and this is one area where some further research will be required in the future.

Trees planted on yellow and stunted Imperata grassland sites or where ferns are thick, display yellow leaves and retarded growth, symptoms of nitrogen deficiency. Sites that have had tapioca growing on them for some time will produce similar symptoms. Applications of Ammonium sulphate will assist the plants in a short time. Applications of NPK will also be beneficial.

Stunted tip growth and leaf die back associated with boron deficiency has been observed but the plants either die or recover over a period of several months.

Balsa has been grown for several rotations on one site for over 15 years in the Keravat plantations with little evidence of decrease in growth with each new generation. Since Balsa is such a fast grower and produces very strong and active surface roots, it is expected that at some point in time the soil fertility will decrease and that fallowing and fertilisers must be used. It is suggested that in the absence of good data that the local Agriculture Department be contacted for information on the fertiliser requirements for horticultural tree crops such as cocoa in the area, to use as a guide to fertilise Balsa in the area.

4.2.5 Tending

Early and clear tending must be given to promote rapid growth. If the trees are given complete freedom in the initial stage, crown closure is rapid.

4.2.6 Protection against Pests

Protection against the giant snail may be necessary in some areas. Methylaldehyde impregnated cardboard rings have been previously recommended, but there are a number of other effective snail baits in granular form which are commercially available.

Snail baits should only be used if there is a definite giant snail problem as the native snail population can be destroyed. This should be avoided as they are more beneficial.

4.2.7 Fire Protection

Balsa trees do not tolerate fire at any age and they will die if severely burnt at the base. Fire scorch will cause the trees to die on the fire scorch side and develop rot which can affect the first log from ground level to as high as 7 meters, causing rot to develop. Trees affected like this often fall over in time and can be a hazard to powerlines, buildings and people. Growers should take care with fire during exceptionally dry seasons, such as the El Nino to protect their Balsa blocks and plantations from fire at all stages of the trees' development.

5.0 MANAGEMENT

5.1.0 PRUNING AND THINNING

Development in Balsa is rapid and it is essential to maintain a high diameter growth and at the same time encourage the tree to produce the maximum length of defect free, clean bole.

The length of the clean bole produced by the tree and the reduction of stem defects depends on the initial spacing distances. Initial spacing from 3 metres upwards, using unimproved stock, slows down bole length production and increases the incidence of stem defects including poor stem form.

The 2 x 2m and 2.1 x 2.1m planting distance used to establish Balsa produce the best clear log lengths by age 1.5 years, and there are fewer defects and less poor stem form. Without thinning beyond this age, the diameter growth of the Balsa slows down and there is a loss in volume production.

Spacing at 2.5 x 2.5m and 3.0 x 3.0m planting distance are recommended. Fewer trees per hectare are required and fewer trees need to be thinned to waste. Because of the wider spacing, the growth and volume production will be better over a shorter period (refer to section 5.1.3 (ii) below for more details).

To promote maximum growth among the trees, the plantations must be thinned to a schedule and in such a manner to retain the best trees until clear falling.

Currently village plantations are left un-thinned up to age three years and then clear felled. This system does not necessarily get the best production from the plantation owners. Systematic selective thinning based on a schedule is to be encouraged so as the farmer can get more volume and a better monetary return for his planting over a period of 5-6 years.

5.1.1 Pruning (Figure 2)

Pruning has not been recommended in past treatments as Balsa is usually an early self pruning tree species. However, in recent years, some seed sources have been identified which consistently produce persistent short branches on the lower and even the upper bole of the tree in addition to the normal sets of larger branches.

If left on the tree for a long time, these branches will die and be occluded into the stem to create defects that will prevent the recovery of sound clean knot free wood. Some plantation thinnings have been totally rejected because of this problem, resulting in loss of resource for the mills and loss of revenue for the farmer. Further, such plantation trees will have to be left for up to 5 years before they can be of any use, and even then, recovery of good wood may be small.

PRUNING TECHNIQUES

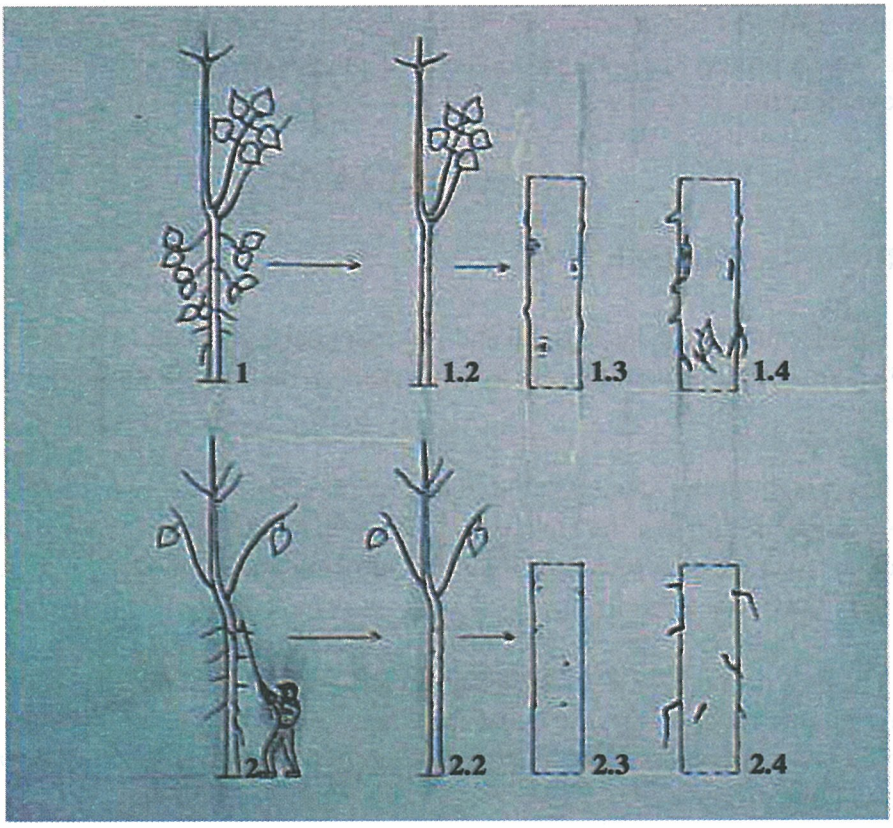

Figure 2: **(1-1.2)** Removal of green branches. **(1.3)** Pruning done correctly with no protruding stubs and no stem damage. **(1.4)** Pruning done incorrectly - exposed stubs and stem and bark damage. **(2-2.2)** Removal of persistent dead branches with a pole hook (or shears). **(2.3)** Removal done correctly with no prominently exposed stubs. **(2.4)** Removal not done properly leaving long branch stubs to be occluded which will cause the logs to be rejected.

Ground pruning is recommended for trees with persistent green and dead branches on the stem from ground level to the first set of large branches (Figures 1 and 2). The pruning of green branches is best done with shears so as not to damage the stem, and at an early age (12 months or earlier) before the Balsa tree produces a large log diameter. Pruning saws can be used with care.

Trees with persistent dead branches may have their branches removed by using a bamboo pole or long stick with a hook fashioned at the end to knock or pull the branches off. This is also called "brashing". Shears on a long pole or pruning saw and ladder can also be used.

Normal sets of branches do not have to be pruned, as these are important for growth and increment. Removal will slow the growth of the tree and even suppress it.

Plantations trees that have demonstrated persistent stem branching and no sign of early shedding of branches should not be used as seed sources.

5.1.2 Fire Prevention

Refer to section 4.2.6 above regarding fire protection.

5.1.3 Selection & Thinning Schedules

(i) Crop stem Selection

The past recommended practice in the plantations planted at 2.0 and 2.1m square spacing has been to select the best 300 stems per hectare prior to the first thinning. These stems are then to be favoured in each thinning so as to remove potential competitors and to promote maximum growth. Potential seed trees are usually identified and marked in this operation. With the introduction of genetically superior stock and 3.0 x 3.0m spacing, this phase is no longer needed.

The ITTO Balsa Project has developed new thinning schedules for the increased planting distances between trees to suit the farmers needs. In both, there is little to no need to select for crop stem selection as the commercial thinning will be done on an alternate diagonal row or alternate row thinning system (Refer to Figures 3 and 4 below).

Marking should only be used in special cases such as marking seed trees and growth and yield plots. The new systems now recommended are as follows:

(ii) Standard Thinning Schedule

In Table 1 below, the following management schedule is the recommended standard thinning schedule for stocking at 2.5 x 2.5m square spacing. Theoretical post thinning spacing is provided as a guide.

TABLE 1

THINNING SCHEDULE FOR 2.5 X 2.5m SQUARE PLANTING

Age (Years)	Stocking Rate	Theoretical Spacing	Purpose of thinning
0	1600 sph	2.5 x 2.5m	----------
1.5	1260 sph	4.2 x 2.1m *	Remove useless trees
3.5	630 sph	4.2 x 4.2m	Commercial thinning
5.00-6.0	clearfall and replant	–	As above

* This combines thinning to waste and a commercial thinning. Diagonal or alternate row thinning can be applied. Seed trees should be selected before thinning and the best 400-600 stems per hectare should be left.

(iii) Recommended Thinning Schedule for Plantations Using Improved Stock

With the introduction of genetically superior stock, the need for planting more stems per hectare and non-commercial thinning should diminish. Selection of the best trees for retention should not be required except for seed trees. In Table 2, the following modified stocking rate at 3 x 3 m square spacing and thinning schedule is recommended.

TABLE 2

THINNING SCHEDULE FOR 3 X 3m SQUARE PLANTING

Age (Years)	Stocking	Spacing	Purpose of Thinning
0	1110 sph	3.0 x 3.0m	----------
3.0	550-450 sph	3 x 6 or 45 x 4.5m	Commercial
5.0-6.0	clear fall and replant	–	Commercial

- This also combines a un-merchantable thinning with commercial thinning.
- Seed trees should be selected before thinning starts.
- Large spaces due to missing trees can be compensated for by retaining some of the trees in the rows to be thinned.
- If poor and useless stems are left in the un-thinned rows, the removal of these can reduce the stock down further to around 400 sph at age 3 and 4 years. This should not be of great concern as such trees are not likely to produce commercial wood in the life of the plantation as demonstrated in Balsa growth and yield plots at age 5 years.

(iv) Diagrammatic Representation of the Recommended Thinning system

FIGURE 3

ALTERNATE DIAGONAL ROW THINNING

ROW	1	2	3	4	5	6	7	8	9	10
	X	•	X	•	X	•	X	•	X	•
	•	X	•	X	•	X	•	X	•	X
	x	•	X	•	X	•	X	•	X	•
	•	X	•	X	•	X	•	X	•	X
	x	•	X	•	X	•	X	•	X	•
	•	x	•	X	•	X	•	X	•	X
	x	•	X	•	X	•	X	•	X	•
	•	X	•	X	•	X	•	X	•	X
	x	•	X	•	X	•	X	•	X	•

X = TREES TO BE THINNED OUT

FIGURE 4

ALTERNATE ROW THINNING

ROW	1	2	3	4	5	6	7	8	9	10
	•	X	•	X	•	X	•	X	•	x
	•	X	•	X	•	X	•	X	•	x
	•	X	•	X	•	X	•	X	•	x
	•	X	•	X	•	X	•	X	•	x
	•	X	•	X	•	X	•	X	•	x
	•	X	•	X	•	X	•	X	•	x
	•	X	•	X	•	X	•	X	•	x
	•	X	•	X	•	X	•	X	•	x
	•	X	•	X	•	X	•	X	•	x

X = TREES TO BE THINNED OUT

5.1.4 Management of Natural Regeneration

In some situations at Keravat, in East New Britain, Balsa plantations have been established using natural regeneration which has established itself following the clear falling of plantation Balsa. Regeneration can be very dense. Over 25,000 trees per hectare have been estimated in growth and yield plots.

The spatial arrangement in these situations is always irregular and the plantation compartment may require additional stock to be inter-planted to fill in large gaps between colonies of natural regeneration.

Border trees in closely spaced colonies of natural regeneration have a tendency to lean out towards the light and are more advanced than inter-planted stock. As a result, poor stem form development may result with reduced merchantable log lengths as well as producing more stem defects. Plantations based on natural regeneration can be just as productive as planted plantations if they are managed at early ages between 6 and 15 months. Removal of unwanted trees should start as soon as the first set of branches have been produced.

For establishment and management purposes, the following should be applied:-

(i) Inter-planting to fill in large gaps in the area, should be carried out within a few weeks of germination of the self sown seed. Spacing to be as recommended for normal plantation establishment.

(ii) Only areas were there is little germination are to be planted.

(iii) Closely spaced colonies are to be thinned between ages 6 to 18 months to increase spacing to 3.0 x 3.0 metres between the remaining trees. A bush pole measuring stick of 3.0 metres length can be used as a guide to spacing between trees to be left.

(iv) Trees with distinct leans are to be removed in the released thinning and if left, they should be removed in a commercial thinning by 36 months, as these can seriously affect the stem form of the adjacent trees.

(v) After this, the management of the plantation is to be based on the standard thinning schedule as outlined in section 4.1.1. Table 1. For assistance in estimating stocking rates by spatial arrangement, refer to the guide chart in appendix 3.

6.0 AGROFORESTRY AND BALSA PLANTATIONS

Agricultural trials have demonstrated that food crops can only be grown under Balsa for the first 3 to 4 months. Such intercropping was found to be beneficial in the control of weeds in the plantation. Balsa should not be considered an agroforestry species but rather a farm forestry species as it does not contribute to the welfare of agricultural crop species in terms of improvement of fertility.

Crops should be planted at least 2 to 3 months before the Balsa planting and only short term crops, such as vegetables and sweet potatoes have been recommended. These have to be established at wider spacings so as not to overshade the Balsa seedlings. Corn, Aibika and Cocoa are not recommended for planting in or near Balsa due to insect related problems. Balsa does not do very well on sites occupied by Tapioc. Kaukau or sweet potato plantings are useful in the suppression of weeds around Balsa seedlings.

Further research work in this field has been recommended by the Agriculture Research Division of DAL (Nevenimo and Moxon, 1992).

7.0 - NOTES ON PLANTATION PROBLEMS

7.1.0 DISEASES

Balsa is susceptible to many of the root diseases that are found in Cocoa. Also, some of these diseases appear to be associated with wet sites where Balsa should not be grown. According to Wood and Lass (1985), there is little prospect of chemical control of these pathogens and infected trees should be promptly removed, including the roots, before neighbouring trees can become infected through their roots.

Generally, good harvesting practice can help reduce infection. This requires that only very short tree stumps should be left standing when the tree is cut down, so as to reduce the breeding area for root rotting fungi. For local farmers, the purchase of fungicide may be beyond their means, but the control on the way the trees are harvested can be applied by the farmers.

For further reading on pathogens refer to Thorold (1973) and Wood and Lass (1985).

(a) Brown root disease

Brown root disease (Phellinus noxius) is a common disease among tree species in PNG and attacks cocoa, rubber and tea as well.

The pathogen infects the roots of Balsa and develops a black fungal skin over the roots and the base of the tree around ground level. The inner wood of the tree becomes discoloured and cannot be used commercially. Infected trees will die rapidly.

(b) Collar crack (Plate 11A-B)

Collar crack (Armillaria mellea) is also a common pathogens of tree and horticultural crops such as Cocoa and is often associated with trees growing on sites that are damp, seasonally wet and poorly drained.

The pathogen infects the root and weakens the anchorage of the trees allowing them to be blown over easily in high winds. The bark often becomes discoloured at the base and splits may occur. Infected trees may have a discoloured and split section in the heart of the log which may render the log useless for marketing.

(c) Red Heart

Balsa trees in the Keravat plantations suffer from a physiological condition known as " Red Heart". This is often associated with root and stem collard rot as well as insect attack at the butt end of the tree. Old bush and grass knife damage has been noted on such trees. People tending Balsa blocks and plantations should avoid damaging trees when cleaning around the trees.

The "Red Heart" condition is a pink. to rose discolouration of the core of the trees and is a serious form of degrade rendering the wood unmarketable. It can occur in trees as young as 3 years old but it is usually more prevalent in trees from 5 years onwards. The presence of this degrade at this age has influenced the choice of clear falling commercial plantations at age 6 years.

No preventative measure have been recommended by pathologists for such problems in the Balsa plantations. However, where trees have been identified with bark rot, and there is exudation at the base of the trunk, these should be removed during thinning operations regardless of size or position in the stand.

(d) Canker

Canker is recognised as a blackened lump or bump of raised bark pieces, usually branches and at the junction of the main branch and a side branch. It sometimes occurs on the main stem.

Trees with such infections may have retarded growth, although their foliage may look healthy. Canker disfigures the wood in the trunk of the tree and therefore, renders the tree useless for harvest. The best cure for such a problem is to destroy the tree by cutting it down and removing it from the plantation. To date, such infections appear to be isolated cases and have not been seen in epidemic proportions.

Plate 11 (A)

Plate 11 (B)

Plate 11 (C)

Plate 11 (D)

Plate 11 A-B: Tree infected by pathogens through the root. The cambial region on left side of the tree is dead and the bark has split with weeping sap in live section. Insect attack is secondary.

Plate 11 C-D: Example of "Red heart" decay in butt log up to 4 metres of stem in a 4 year old natural regeneration Balsa tree.

7.2.0 INSECT PESTS

A number of insects have been recorded as pests of Balsa by Forestry and Agriculture entomologists. No economic control measures have been recommended. However, insect problems were found to increase where Balsa trees were planted close to old cocoa blocks or on sites previously occupied by cocoa (Nevenimo and Moxon, 1992).

The following is a list of insects which have been found associated with damage to Balsa:

(a) Wood borers

Glenea aluensis	Cocoa longicorn
Glenea lefeburei	Longicorn beetle
Pantorhytes plutus	Cocoa weevil

Trees between age 6 to 24 months appear to be quite susceptible to beetle attack and as the tree age, any attacks appear to be associated with trees under stress from other causal agents. In very young trees, drooping and discoloured foliage often indicate that a tree has insect attack. Where this occurs in the green upper section of the tree stem, the surface will be uneven or bumpy and accompanied by sap bleeding.

Beetle grubs attack the cambium or inner bark layer of the tree trunks and leave holes that weep white sap or brown sap and pieces of frass (Plate 13). The grub may circle the entire tree stem and in the young trees may cause top die back (Plate 12).

Providing the attack is not severe or numerous, the grubs can be removed with a thin wire with a sharp hook or barb on the end. A pocket knife can also be used but this may leave a larger scar and leave the tree open to other infections.

Beetle attack usually leaves the wood damaged and stained around the area where the grubs have fed and where the adult beetle emerges. This damage encourages the entry of fungus and rot and can either cause the tree to die or render it useless for timber (Plate 13).

Should the attack severely affect the health of the tree, the tree should be cut down and the bark peeled off to expose the grubs to predators and to prevent the development of the young beetles.

Insects may prove to be a secondary invader in some situations where the tree is being damaged or killed by pathogens. (Plate 11 A-B). The insects may be Longicom beetles or Platypodid or powder post beetles. The latter will attack commercial logs left too long on the ground and render them useless for milling. The same beetles rapidly attack trees struck by lightening.

(b) <u>Defoliators</u>

Sylepta derogata Aibika leaf roller (Plate 14)

The grub of this pest cuts and rolls a tubular nest from the margins of the leaf. So far this has not proved to be a serious pest and often appears mainly to be associated with young trees on poor sites.

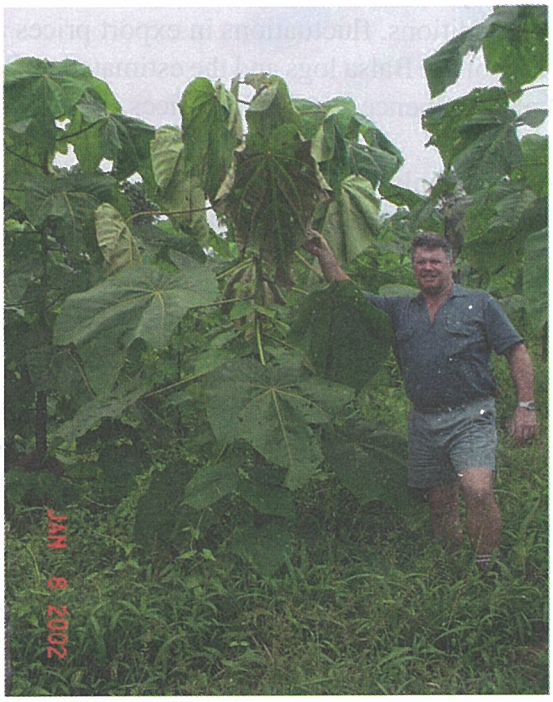

Plate 12: Longicorn attack on stem of 3 month old balsa causing top death

Plate 13: Longicorn infestation of butt a 4 year old tree.

Plate 14: Leaf Roller infestation

8.0 NOTES ON MARKETING

No large scale Balsa planting in any province should be encouraged unless there is a mill in the region that will purchase and process Balsa for sale in the country and overseas. Presently there is very little demand in PNG and most Balsa sawn and processed in PNG is exported.

Prices for Balsa logs may vary considerably from time to time due to fluctuation in the local currency, haulage distances and road conditions, fluctuations in export prices and the level of overseas demand. The age and quality of the Balsa logs and the estimated amount of recovery of good Balsa from the logs will also influence purchasing prices.

Processed Balsa marketing is currently done only by the processing companies and not by the Forestry service, however, the Forestry service may provide some service in assisting potential processors to locate markets.

8.1.0 Selling Balsa to the Mills

Where several mills are purchasing Balsa in a region, the Balsa growers seek and negotiate for the best prices. Purchasing agreements (in triplicate) are held by the purchaser which are to be signed by both the purchaser and the grower once a price has been agreed to. The buying price is recorded on the agreement. The original white copy is held by the grower and resource owner, a green copy goes to the Provincial Forestry office for their records and in case of disputes over prices. A yellow copy is retained by the company. These purchasing agreements should be used at all times when selling Balsa logs. For further information, the Provincial Forestry Office and Forestry Balsa extension services should be consulted.

Currently, only the merchantable logs are purchased and not the entire tree as there is some loss in volume due to branches and stem defects. Companies purchase short logs in lengths of 1.3 to 2.4 m length and with a minimum top end diameter under bark (DUB) sizes between 16 to 17cm. Logs as short as 0.9 metres are sometimes accepted.

A set of log volume tables is provided in Appendix 4 for calculating the volume of logs cut at lengths accepted by the Balsa companies for milling.

8.1.1 Log harvest records

As with purchasing agreements, these are in triplicate and the logs harvested are marked on the sheet by diameter and log length classes. Copies go to the resource owner, the Provincial Forest Office and a copy is retained by the purchasing company or its representative. For further information, the Provincial Forestry Office and the Forestry Balsa extension services should be consulted.

9.0 NOTES ON ENVIRONMENTAL IMPACT ASPECT

Because Balsa trees seed so freely, the seeds can migrate long distances and produce dormant seed Banks which produce dense natural regeneration (over 25,000 seedlings per ha). The species is regarded as a weed species that has the potential to adversely affect the environment by shading out and replacing native plants and removing fauna habitat.

Dense regeneration of Balsa can suppress competition from other trees and shrubs as well as suppressing much of the flora in the lower story. However, competition and natural selection in these situations can result in a mixed stand of Balsa and other flora.

In its natural habitat, Balsa is regarded as a nurse species allowing natural forest species to establish as an under story on previously disturbed sites. These native species will ultimately succeed following the death of the Balsa whose natural life span may range from 30 to 40 years (in PNG). Plantation grown Balsa is usually accompanied by natural regeneration of indigenous species which can dominate the Balsa plantations in some cases if not controlled. Late arriving natural regeneration of some indigenous species are often suppressed but not necessarily killed by competition and later succeed with the thinning of the Balsa.

Balsa can be controlled by poisoning and cutting unwanted natural regeneration. Due to this, it is not regarded as a potential threat to the environment. Natural attrition due to diseases, insects and the elements will also control the spread of Balsa. Decomposition of Balsa trees is rapid and large trees of 50cm diameter may totally collapse with decay within 1-2 years creating mulch and contributing to the fertility of the soil.

Generally, Balsa has the potential to be of benefit to the environment, due to its rapid growth and surface root system through soil stabilisation. Further, as one of many fast growing tropical trees, of its potential contributions to the environment that appears not to have considered by many, is the net absorption of carbon dioxide from the atmosphere, and storage of carbon in its wood or wood products, which is needed to help the reduction of global warming caused by the green house effect. Since wood contains carbon as a major component, the expansion of fast growing and easily replaced Balsa plantations could lead to significant fixation and storage of this element.

10.0 NOTES ON GROWTH AND YIELDS

People curious to learn about Balsa in PNG usually ask the same questions which are related to where Balsa grows in PNG, the best growing conditions, how fast will it grow, what are the expected yields at certain ages, how much money will they receive?

Balsa growers like to know if their Balsa is performing well and what yields they are likely to get from their Balsa block. Performance and yield depend on a number of things such as batch vigour (stock quality and origin), health, location and site quality (fertility and drainage), initial spacing at planting and management. The following facts and figures will provide some answers to these questions.

(i) Where does Balsa Grow in PNG?

Balsa is an introduced species that has been officially trialed by the former Forestry Department (now the National Forest Service) in the Central, Morobe, East Sepik, Sandaun, West and East New Britain, and New Ireland Provinces. Its introduction into Manus Province appears to be a private one. Out of interest and curiosity, people have also introduced Balsa into other provinces, so that one may find Balsa growing in areas not generally recommended for growing the Balsa tree. Balsa has been planted in some of the Highlands Provinces. It is known to have been grown in the Eastern Highlands province at Goroka at around 1,500 metres above sea level, and in the Southern Highlands at a lower altitude.

(ii) What are the Best Growing conditions in PNG?

Generally, the tree gives the best growth performance if grown at altitudes between sea level and 700m. Optimum growth can be expected at altitudes between 10 and 200m in altitude. From the Goroka introductions, it is obvious that they can tolerate cold nights, but growth is reported to be exceptionally slow. Balsa will grow in areas with rainfalls from 1600mm to 6,000mm per annum (such as in Pomio) but it does not like growing in areas that also have a long dry season.

The most important thing to remember is that Balsa does not like wet or temporarily wet conditions, or shallow soils and soils with a high clay content. Balsa likes fertile, well drained soils and climatic conditions that produce only short dry seasons but with plenty of sunshine. Balsa does not like strong windy conditions as these can push trees over, break their tops or snap them off.

(iii) Can Balsa be grown on new Volcanic Soils?

This is included for the benefit of the people living around Rabaul and Vulcan volcanoes in East New Britain.

- Balsa is extremely sensitive to fresh volcanic ash and will suffer defoliation usually resulting in death.

- Balsa planted on volcanic soils can survive but growth may be nil or slow unless provided with some shade and good rainfall.

- Balsa planted on volcanic soils in the company of shade trees such as Trema or Gliricidia are more likely to succeed and can produce good healthy growth. The possible problem in these situations is soil temperature, which is high in open situations and appears to inhibit root development in the Balsa seedling.

(iv) How fast does a Balsa tree grow?

- Height growth is around 1.5m a month.
- Trees attain an average height of around 22.5m at age 36 months and around 27m at age 48 months.
- Diameter growth at age 1 to 2 years can range from I - 1.5cm a month and there have been occasional records of close to 2cm a month. Usually, if the conditions are good at this age, then 1cm a month average is considered good.

- Diameter growth at age 3 years may slow to an average of around 0.6cm. Trees which show less than 0.4cm per month, and are less than 19cm diameter, are considered suppressed and useless as a commercial tree.
- Best diameter sizes attained around 36 months on record are 41 to 50cm diameter over bark at breast height.

(v) How much Volume can One Tree Produce?

This will depend on the quality of the seed batch used to produce the tree, the age of the tree, and the growing conditions of that tree.

- Recovery from trees around age 30 to 36 months will only yield around 25-35% commercial wood from its total volume.
- Recovery from trees older than this, or large trees at 36 months can yield as much as 60% commercial wood from their total volume as more wood can be recovered from the upper crown.
- At age 30 months in a plot planted at 3 x 3m and stocked at 770 trees per hectare, with an average height of 22.7m and an average stem diameter at breast height of 23.76cm, the average tree volume recovered was 0.36 cubic metres.
- At age 36 months, in a plot planted at 2.5 x 2.5m and stocked at 710 trees per hectare, with an average height of 22.6m and an average stem diameter of 23.94cm at breast height, the average tree volume recovered was 0.28 cubic metres. In this particular plot, the largest tree with a diameter of 41cm over bark gave a yield of just over 0.7 cubic metres.
- Larger trees around 4 years of age with an average height of 27m and diameters around 40 to 45cm diameter at breast height over bark produce between 0.8 to 1.6 cubic meters per tree.

(vi) How much Volume can be expected from a hectare of Balsa Trees?

This is a difficult question to answer because the yield will depend on a number of things such as the seed source, age, initial plant spacing, stocking at time of thinning, growth rate, site quality and general growing conditions and the management and maintenance applied.

- At 30 months, planted at 3 x 3m and with a survival of 770 stems per hectare, the estimated recoverable merchantable volume is approximately 250 cubic metres per hectare.
- If managed as per the thinning schedules over 5 year period, the same plot would yield a total of 450 cubic metres of merchantable volume, with the potential to produce upwards to 600 cubic metres over the same period if thinned at age 36 months and clear felled at 5 -6 years.
- A plot at age 36 months, planted at 2.5 x 2.5m and with a survival of 710 stems per hectare, would yield a total of merchantable volume of 178 cubic metres, if clear felled at that age.
- The same plot managed and thinned as per the schedules at age 5-6 years would yield a total of 387 cubic metres, with a potential of producing up to 500 cubic metres over the same period if thinned at age 36 months and 5 - 6 years.

(vii) How much will a farmer earn from his Balsa?

Prices for round wood Balsa log vary from mill to mill, the quality of the log and the distance to cart the logs to the mill can be expected to influence prices. As of 2002, buying prices in the Gazelle Peninsula of East New Britain ranged from K20 to K50 per cubic metre.

- Log volume will depend on size of the trees and their age.
- Old age stands older than 6 years are likely to fetch a lower price per cubic metre.
- Trees with "Buks" from occluded branch stubs will most likely be rejected.
- Trees with top end under bark diameters of less than 16 - 17cm will most likely be rejected.
- An estimated value of between K11,500 and K13,500 per hectare at age 5 years has been estimated at a rate of K30 per cubic meter of log.

(viii) Do volume tables exist to help farmers calculate their log and tree volumes?

Volume table exist that can be used to calculate the volume of Balsa logs of standing trees and also the harvested logs. For further information, farmers should contact their local Forestry Office for information on where to apply to purchase these. The Balsa Extension unit at Keravat can be of assistance.

(ix) Why is it important to use the best seed source for producing stock for planting?

In agriculture and in forestry, it has been demonstrated that some seed sources of food crops and trees perform better and are more productive than other seed sources. In the case of Balsa, the ITTO project has demonstrated in its trial plantings that poor survival, form, growth and productivity is often associated with seed source. For example, in table 3 below, growth figures and the total volume harvested from growth and yield plots at age 36 and 48 months, for Oomsis (Lae, Morobe province) and Keravat (East New Britain province), showed that the Keravat seed source was more productive than the Oomsis seed source at the same age and on the same sites.

Table 3. Comparison of Productivity Between Oomsis and Keravat Seed Sources Keravat National High School Balsa Plantation By age 48 Months.

Plot	Source	Age (months)	Stocking at Final Harvest	Trees Thinned (effective) *	Mean Ht (Metres)	Mean Diameter O/bark	Total Yield/ha Cubic metres
1	Oomsis	48	41	41(30)	24.3	33.05	288.77
2	Keravat	48	51	51(49)	27.4	28.39	455.20
3	Oomsis	48	31	31(23)	26.0	34.40	243.00
4	Keravat	48	41	41(35)	26.6	30.34	338.40
5	Oomsis	48	38	38(34)	23.9	29.20	243.20

Notes on Growth and yield plot figures above

*Effective stems are those that are of commercial size and are enclosed in brackets.

The following should be noted in table 3 above:

- All trees are planted at 3 x 3m square spacing.
- Plots 1 and 2 are paired plots on a good site and plots 3 and 4 are paired plots on a slightly poorer site. Plot 5 is a spare plot on an average site.
- The lower stocking for the Oomsis seed source is due to a higher incidence of deaths due to weak and weedy trees in that batch. Keravat had a lower incidence of weak and weedy trees and mortality among these trees, and consequently the number of effective or commercial stems is higher in the Keravat seed source.
- The slightly better mean diameter of the first two Oomsis plots can be directly attributed to the lower stocking in these plots and therefore, less competition for the survivors.
- Keravat seed sources gave a higher yield than any of the Oomsis stock. These results are consistent with those of other plantings of the Oomsis seed source.

GLOSSARY
(Based on Schmidt, 1994 and Wright, 1976)

Anther: The male organ of a flower bearing a sac that holds pollen grains that are released when the sac ruptures.

Agroforestry: Any land-use which combines the growing of food and tree crops. Usually the crops are complimentary.

Amplitude (environmental): extent, range or limits of altitude, rainfall, soil conditions required by species of either flora or fauna and under which they grow in nature.

Ascending axis: The main stem of a tree, or any other plant, growing upwards.

Beating up: The establishment operation of replacing plants that have failed (died) in the first few months of planting: also referred to as refilling and blanking.

Bole: The trunk of a tree from ground level up to the first set of branches.

Brashing: A form of low pruning to about 2 m up the stem. The term is sometimes confined to meaning the removal of dead branches which can easily be knocked off rather than sawn off.

Buk: A Pisin English term referring to a pronounced bump on the stem of a tree caused either by an a branch stub that has been gown over or by a disease such as canker.

Candidate seed tree: A tree that has been selected for grading because of its phenotypic qualities but has not yet been graded or tested to see if it qualifies for seed tree status.

Certified tree seed: Seed collected from trees of proven genetic superiority, as defined by a certifying agency, and produced under conditions that assure genetic identity. These could come from seed trees in a seed orchard, or from superior trees in plantation stands or seed gardens.

Character (trait): A distinctive but not necessarily invariable feature exhibited by all individuals of a group and capable of being described or measured: e.g. color, size performance. A character of a given individual will have a certain phenotype (state) as determined by the individual.

Comparison or check tree: Trees that are located in the same stand are nearly the same age, are growing on the same or better site as the select tree and against which the select tree is graded. Trees chosen as comparison trees are the best trees in the stand, with characteristics similar to "crop" trees that would be chosen in a silvicultural operation.

Corolla: The petals of a flower, collectively forming the inner whorl of the perianth. It encircles the anthers and the stamen. The petals may be free or fused to form a tube.

Commercial Thinning: Cutting trees out to be sold to the mill.

Crown break: A term used to describe the point where the merchantable log or bole of the tree terminates. Usually where the tree produces permanent branches or a double top.

GLOSSARY (Cont.)

Culling: Systematic removal of individuals not desired for the perpetuation of a population.

Diameter breast Height over bark (DBHOB): A standard point of measure on the trunk of a tree to measure the diameter over the bark. This point is 134 cm from the bottom of the tree and from the highest side of the base of the tree at ground level.

Diameter breast height under bark (DBHUB): As above but with the bark removed at the point of measure when the tree is cut down.

Distancing: The operation of making sure that the trees are planted at the correct distance apart - Spacing.

Diversity: The condition of being different, showing differences.

DOB: Diameter measured over bark.

DUB: Diameter measured when the bark has been removed

Elite tree: A tree verified by appropriate testing as being highly superior or desirable for a specified environment and breeding program. Verification can be done by evaluation of progeny of by clonal tests.

Establishment: All operations undertaken to get a stand of trees growing healthily on site.

Even - aged: All trees of the same or very similar ages.

Family (seed tree family): The offspring of a single tree after open pollination or a single pair of trees after controlled pollination .

Family selection: The selection of progeny families on their mean performance. In addition, the best individuals are usually selected in the best families.

Flowering period: The honological period from the appearance of flowers to fruit set. Flowering may be prolonged (diffused) or short (masting).

Forest tree breeding: Applying knowledge of genetics to develop improved trees using various breeding systems including artificial pollination.

Forest tree improvement: Usually synonymous with forest tree breeding, but may refer to tree breeding in combination with cultural practices.

Form: Shape, especially straightness and taper, of a stem of a tree.

Gene bank: A collection of elite, plus and sometimes special trees maintained for present future use in genetics and tree breeding.

GLOSSARY(Cont.)

Gene conservation: Protection and maintaining the genetic variety of a species in order to keep a genetic resource for future research and improvement, e.g. disease resistance and vigour.

Genetic resources: Genetic material (trees or populations) of actual or potential value for improving the quality of trees or resistance to diseases and pests or improving and maintaining vigour.

Gene pool: A collection of trees from documented different seed sources of actual or potential value for tree improvement and maintenance of vigour as a genetic resource. Also expressed as the total sum of all the genes and their alleles present in a breeding population or species at one time.

Genetics: Genetics is the basic science dealing with causes of resemblances and differences among organisms related by decent. It takes into account the effects of genes and environment. When the basic knowledge of genetics is applied to breeding trees, the effort is preferably referred to as forest tree breeding, tree breeding or tree improvement.

Genotype: (1) An individual's hereditary constitution, with or without phenotypic expression of the one or more characters it underlies. The genotype is determined chiefly from the performance of the progeny and other relatives. It interacts with the environment to produce the phenotype. (2) Individuals characterised by a certain genetic constitution.

Geographic race: A race native to a geographic region (see Ecoptype, Land race, Local seed source, Provenance, Race, Seed source).

Grading system: System of assessment of traits of select trees in a stand. The system contain objective measures or subjective assessments as compared to comparison/check trees.

Habit (Plant): The general appearance of a plant, whether erect, prostrate, climbing, etc.

Harden off: Part of a conditioning process in which the nursery regime allowing good growth (shade and watering) is partially reduced with the intention of making the seedling hardier.

Improved: A nontechnical term often referring to open pollinated seed from selected trees.

Individual selection: From a family or population, single plants are selected on their own merit as parents or ortets. Sometimes called phenotypic selection.

Inheritance: The acquisition of characters or qualities by transition from parent to offspring.

Intercropping: Growing two crops at once e.g. food crops among trees.

Internode: The length of stem between two distinct whorls of branches.

GLOSSARY (Cont.)

Kapok: A dense collection of fine hairs like cotton, encasing a seed or seed. This functions as a means to disperse seed on the wind over a long distance from the mother tree.

Monoculture: Growing a crop (plantation) of only one species, i.e. pure crops.

Monoecious: Describing plant species that have separate male and female flowers or bisexual flowers on the same plant.

Natural regeneration: Re-establishing a tree crop by natural means i.e. not by replanting.

Ortet: The original plant from which a clone has been derived.

Outbreeding (outcrossing): The production of off-spring by the fusion of distantly related gametes.

Perianth: The part of a flower situated outside of the sexual organs of a flower.

Petiole: The stalk that attaches the leaf blade to the stem of the plant. Those without a petiole are referred to as being sessile.

Phenology: The study of relations between plant development and seasonal climatic changes, such as temperature or day length, especially how such changes effect periodic phenomena like leafing, flowering and dormancy.

Phenotype: The plant or character as we see it; state, description, or degrees of expression of a character; the product of the interaction of the genes of an organism (genotype) with the environment. The phenotype describes the individual when the total character expressions of an individual are considered. Similar phenotypes do not necessarily breed alike.

Plant breeding: The improvement of plant production through selection and controlled propagation, e.g. cross pollination.

Plus: Appearing distinctly superior to the average. The term is used for describing phenotypes of both stands and single trees. The superior characters should be specified i.e., plus for volume, quality, pest resistance, or combination of characters.

Population: Genetically, a group of similar individuals related by decent and so delimited in range by environmental or endogenous factors to be considered a unit. Also referred to as the interbreeding group.

Pricking out: Transfer of tiny seedlings from the tray where they germinated to a permanent growing medium in the nursery e.g. in a filled container.

Progeny: Offspring, on next generation; all plants and animals are the progeny of their parents.

GLOSSARY (cont.)

Provenance: (1) The original geographic source of the seed, pollen or propagules. The term is used to refer to the original native source of a population. When a population is removed from its sources and propagated elsewhere, it is referred to as a "land race". (2) The place in which any stand of trees are growing.

Red Heart: Rusty red stain in the core of a Balsa tree associated with incipient decay. This usually produces a smell of rot and is sometimes accompanied by a watery exudation of dark or rusty red sap.

Reproductive age: The age at which the tree produces its first fruit crop.

Roguing: See **Culling.**

Seedling seed orchard (SSO): Seed orchard raised from seedlings produced from selected parents through natural or controlled pollination.

Seed collection area: An area with defined boundaries and attitudinal limits in which soil and climate are sufficient uniform to indicate a high probability of reproducing a single ecotype.

Seed garden: Usually a stand established from seed or grafts to be used specifically for seed production. This is a general term used to cover all forms of seed orchards and seed stands and seed production areas.

Seed Orchards (SO): A plantation consisting of clones (CSO) or seedlings from selected trees (SSO), isolated to reduce pollination from outside sources, rogued of undesirable specimens and cultured for early and abundant production of seed.

Seed production area (SPA): Same as a seed stand. A plus stand that is usually upgraded by culling.

Seed stand: The stand of trees growing in a seed production area.

Seed trees: Mother trees that have been rigidly selected for promising phenotypic characteristics.

Selected seed tree seed: Seed collected from trees that have been rigidly selected for promising phenotypic characteristics but have not been progeny tested.

Selection intensity: The proportion of individuals in the population that are selected.

Select, superior or plus tree: A tree that has been recommended for production or breeding orchard and graded as follows; it has a superior phenotype for growth, form and wood quality, or other desired characteristics and appears adaptable. It usually has not been tested for its genetic worth, but its chances of having a good genotype are high.

GLOSSARY(cont.)

Silvicultural system: The way a forest is managed or worked to yield certain forest products and be regenerated.

Spadix: A flowering shoot with a large fleshy floral axis bearing small, usually unisexual flowers, characteristic of the lily family.

Stand: Refers to a group of standing trees. A plantation or an area of trees of a single species.

Standing out: Removing seedlings into the open when they no longer require special care and protection.

Stigma: The glandular sticky surface at the tip of a carpel of a flower which receives the pollen.

Stocking: Number of trees per unit area.

Style: The stalk of a carpel between the stigma and the ovary.

Thinning: The removal of trees by cutting them down. Also the name given to a tree that has been cut down.

Thinning (selective): Trees are thinned or left depending on the subjective judgement of the persons doing the thinning. Intensity of thinning and the kind of tree favoured can be varied according to the rules of a thinning schedule.

Thinning (systematic): Mechanical or line thinning. Trees are thinned following an objective and systematic procedure in which the individual tree quality is not considered unless it is a candidate seed tree or trees need to be retained to compensate for large gaps.

Thinning to waste: The thinning of trees that have no commercial value. Usually sick trees and useless trees that cannot be sold to the mill. This is usually applied in plantations to give the better trees more room to grow.

Unmerchantable thinning (UMT): The same as thinning to waste (above).

Variety: A taxonomic subdivision of a species based on minor characteristics and often an exclusive geographic range.

Vigour (vigor): Healthy, profuse and rapid growth.

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APPENDIX 1

LIST OF BALSA INTRODUCTIONS INTO PNG

No	Source	Date	Planting Locations
1.	Milner's Balsawood (Queensland)	1947 or 1948	L.A.E.S Keravat
2.	Perideniya (Sri Lanka)	As above	As above
3.	Oatacumund (Madras, India)	1950 or 1951	Cpt 3 Fryar. Keravat East New Britain
4.	Lancetilla Gardens (Honduras)	1953	Cpt 13 Fryar, Keravat
5.	South Johnstone (Queensland)	1954	No record (only 6 seedlings raised)
6.	Sarmi North Coast (Irian Jaya)	1955	Cpt 15 Fryar, Keravat
7.	Kota Nica (Irian Jaya)	1961	No record (Batch considered same as 5)
8.	Bogor (Indonesia)	1961	Cpt 15 Kamarere Kerevat
9.	Lae B.G. (Ex. Sarmi)	1961	Corrective Inst. Keravat
10.	Colombia	1974	Cpt. 1 Little Vudal, Keravat and Warongoi East New Britain

APPENDIX 2
PLUS TREE ASSESSMENT RECORD SHEET
PLUS TREE SELECTION - BALSA

OFFICER DATE REF. NO

TREE NO. LOCALITY LOGGING AREA COMPT.

YEAR OF PLANTING DBHOB TOTAL HT. LOG LENGTH

STAND DESCRIPTION (SITE QUALITY AND HEALTH)

SOIL DRAINAGE

TREE DESCRIPTION

	POINTS Possible	Allocated		POINTS Possible	Allocated
A. Vigour Volume advantage over neighbour with 30 metres 30%	60		B. Stem Merch Log Length x 100 oif Total Ht. 75%	20	
20 - 30%	30		60%	15	
10 - 20%	10		50%	10	
B. Apical Dominance Strongly Dominant	20		C. Clear Log Length More than 4 metres	15	
Moderately Dominant	15		Four metres	10	
			Three metres	5	
C. With No Evidence 1 disease on insects	10		D. Kinks & Sweeps Absent	15	
			Slight above 10m	10	
			Slight above 5m	5	
D. Crown Dominant	10				
Co - Dominant	5		E. Knots or Nodes Absent	20	
			One set present	15	
			Two sets	5	
			F. Fluting Absent	15	
			One slight up to 10m	10	
			One glight up to	5	
SUB TOTAL	100		SUB TOTAL	100	
A. Branchlets Absent	15				
Present - Weak	10				
Present - Strong	0				
REJECTED					
ACCEPTED					

Output From Trees Within 10 Metres Radius	Comparison Trees within 10 metres Radius
Row DBHOB. TOTAL HT. LOG LGTH. 1 2 3 4 5	

APPENDIX 3
PLANT SPACING AND STOCKING RATES.

TREES(M)	SQUARE	TRIANGLE	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	TREES(M)
ROWS(M)																			ROWS(M)
1.0	10,000	11,550	10,000																1.0
1.5	4,444	5,133	6,667	4,444															1.5
2.0	2,500	2,888	5,000	3,333	2,500														2.0
2.5	1,600	1,848	4,000	2,667	2,000	1,600													2.5
3.0	1,111	1,283	3,333	2,222	1,667	1,333	1,111												3.0
3.5	816	942	2,857	1,905	1,429	1,143	952	816											3.5
4.0	625	722	2,500	1,667	1,250	1,000	833	714	625										4.0
4.5	494	571	2,222	1,481	1,111	889	741	635	556	494									4.5
5.0	400	462	2,000	1,333	1,000	800	667	571	500	444	400								5.0
6.0	278	321	1,667	1,111	833	667	556	476	417	370	333	278							6.0
7.0	204	236	1,492	952	714	571	476	408	357	317	286	238	204						7.0
8.0	156	180	1,250	833	625	500	417	357	313	278	250	208	179	156					8.0
9.0	123	142	1,111	741	556	444	370	317	278	247	222	185	159	139	123				9.0
10.0	100	116	1,000	667	500	400	333	286	250	222	200	167	143	125	111	100			10.0
11.0	83	96	909	606	455	364	303	260	227	202	182	152	130	114	101	91	83		11.0
12.0	69	80	833	556	417	333	278	238	208	185	167	139	119	104	93	83	76	69	12.0
ROWS(M)																			ROWS(M)
TREES(M)	SQUARE	TRIANGLE	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	TREES(M)

NUMBER OF TREES PER HECTARE

RECTANGLE SPACING
TRIANGLE SPACING
SQUARE SPACING

SPACING IN METRES

APPENDIX 4
VOLUME CALCULATION TABLES
FOR
BALSA LOGS
(Lengths in metres. Diameters in centimeters)

BALSA VOLUME TABLES 0.8m length			BALSA VOLUME TABLES 0.9m length			BALSA VOLUME TABLES 1.1m length		
Diameter	Tally	Volume	Diameter	Tally	Volume	Diameter	Tally	Volume
17	1	0.0181	17	1	0.0204	17	1	0.0250
18	1	0.0203	18	1	0.0229	18	1	0.0280
19	1	0.0227	19	1	0.0255	19	1	0.0312
20	1	0.0251	20	1	0.0282	20	1	0.0346
20	1	0.0277	21	1	0.0311	21	1	0.0381
21	1	0.0304	22	1	0.0342	22	1	0.0418
22	1	0.0332	23	1	0.0374	23	1	0.0457
23	1	0.0362	24	1	0.0407	24	1	0.0498
24	1	0.0392	25	1	0.0441	25	1	0.0540
25	1	0.0424	26	1	0.0478	26	1	0.0584
26	1	0.0458	27	1	0.0515	27	1	0.0630
27	1	0.0492	28	1	0.0554	28	1	0.0677
28	1	0.0528	29	1	0.0594	29	1	0.0727
29	1	0.0565	30	1	0.0636	30	1	0.0778
30	1	0.0604	31	1	0.0707	31	1	0.0830
31	1	0.0643	32	1	0.0724	32	1	0.0885
32	1	0.0684	33	1	0.0769	33	1	0.0941
33	1	0.0726	34	1	0,0817	34	1	0.0999
34	1	0.0769	35	1	0.0866	35	1	0.1058
35	1	0.8148	36	1	0.0916	36	1	0.1120
36	1	0.0860	37	1	0.0967	37	1	0.1183
37	1	0.0907	38	1	0.1020	38	1	0.1248
38	1	0.0955	39	1	0.1075	39	1	0.1314
39	1	0.1005	40	1	0.1131	40	1	0.1382
40	1	0.1056	41	1	0.1188	41	1	0.1452
41	1	0.1108	42	1	0.1247	42	1	0.1524
42	1	0.1161	43	1	0.1307	43	1	0.1597
43	1	0.1216	44	1	0.1368	44	1	0.1673
44	1	0.1272	45	1	0.1431	45	1	0.1749
45	1	0.1329	46	1	0.1495	46	1	0.1828
46	1	0.1388	47	1	0.1561	47	1	0.1908
47	1	0.1447	48	1	0.1628	48	1	0.1991
48	1	0.1508	49	1	0.1697	49	1	0.2074
49	1	0.1571	50	1	0.1767	50	1	0.2160
50	1	0.1634	51	1	0.1838	51	1	0.2247
51	1	0.1699	52	1	0.1911	52	1	0.2336
52	1	0.1765	53	1	0.1985	53	1	0.2427
54	1	0.1832	54	1	0.2061	54	1	0.2519

VOLUME TABLES
FOR
BALSA LOGS
(Lengths in metres. Diameters in centimetres)

BALSA VOLUME TABLES 1.2m length			BALSA VOLUME TABLES 1.3m length			BALSA VOLUME TABLES 1.4m length		
Diameter	Tally	Volume	Diameter	Tally	Volume	Diameter	Tally	Volume
17	1	0.0272	17	1	0.0295	17	1	0.0318
18	1	0.0305	18	1	0.0331	18	1	0.0356
19	1	0.0340	19	1	0.0368	19	1	0.0397
20	1	0.0377	20	1	0.0408	20	1	0.0440
21	1	0.0416	21	1	0.0450	21	1	0.0485
22	1	0.0456	22	1	0.0494	22	1	0.0532
23	1	0.0499	23	1	0.0450	23	1	0.0582
24	1	0.0543	24	1	0.0588	24	1	0.0633
25	1	0.0589	25	1	0.0638	25	1	0.0687
26	1	0.0637	26	1	0.0690	26	1	0.0743
27	1	0.0687	27	1	0.0744	27	1	0.0802
28	1	0.0739	28	1	0.0800	28	1	0.0862
29	1	0.0793	29	1	0.0858	29	1	0.0925
30	1	0.0848	30	1	0.0919	30	1	0.0990
31	1	0.0906	31	1	0.0981	31	1	0.1057
32	1	0.0965	32	1	0.1045	32	1	0.1126
33	1	0.1026	33	1	0.1112	33	1	0.1197
34	1	0.1090	34	1	0.1180	34	1	0.1271
35	1	0.1155	35	1	0.1250	35	1	0.1347
36	1	0.1221	36	1	0.1323	36	1	0.1425
37	1	0.1290	37	1	0.1397	37	1	0.1505
38	1	0.1361	38	1	0.1474	38	1	0.1588
39	1	0.1434	39	1	0.1553	39	1	0.1672
40	1	0.1508	40	1	0.1633	40	1	0.1759
41	1	0.1584	41	1	0.1716	41	1	0.1848
42	1	0.1663	42	1	0.1801	42	1	0.1940
43	1	0.1743	43	1	0.1888	43	1	0.2033
44	1	0.1825	44	1	0.1976	44	1	0.2129
45	1	0.1909	45	1	0.2067	45	1	0.2227
46	1	0.1994	46	1	0.2160	46	1	0.2327
47	1	0.2082	47	1	0.2255	47	1	0.2429
48	1	0.2171	48	1	0.2352	48	1	0.2533
49	1	0.2263	49	1	0.2451	49	1	0.2640
50	1	0.2356	50	1	0.2552	50	1	0.2749
51	1	0.2451	51	1	0.2655	51	1	0.2860
52	1	0.2548	52	1	0.2761	52	1	0.2973
53	1	0.2647	53	1	0.2868	53	1	0.3089
54	1	0.2748	54	1	0.2977	54	1	0.3206

APPENDIX 4 (Cont.)
VOLUME TABLES
FOR
BALSA LOGS
(Lengths in metres. Diameters in centimeters)

BALSA VOLUME TABLES 1.5m length			BALSA VOLUME TABLES 1.6m length			BALSA VOLUME TABLES 1.7m length		
Diameter	Tally	Volume	Diameter	Tally	Volume	Diameter	Tally	Volume
17	1	0.0340	17	1	0.0363	17	1	0.0386
18	1	0.0387	18	1	0.0407	18	1	0.0434
19	1	0.0425	19	1	0.0454	19	1	0.0483
20	1	0.0471	20	1	0.0503	20	1	0.0536
21	1	0.0519	21	1	0.0554	21	1	0.0590
22	1	0.0570	22	1	0.0608	22	1	0.0648
23	1	0.0623	23	1	0.0665	23	1	0.0708
24	1	0.0678	24	1	0.0724	24	1	0.0769
25	1	0.0736	25	1	0.0785	25	1	0.0834
26	1	0.0796	26	1	0.0849	26	1	0.0902
27	1	0.0859	27	1	0.0916	27	1	0.0973
28	1	0.0923	28	1	0.0985	28	1	0.1046
29	1	0.0991	29	1	0.1057	29	1	0.1122
30	1	0.1060	30	1	0.1131	30	1	0.1201
31	1	0.1132	31	1	0.1208	31	1	0.1283
32	1	0.1206	32	1	0.1287	32	1	0.1367
33	1	0.1283	33	1	0.1368	33	1	0.1454
34	1	0,1362	34	1	0.1453	34	1	0.1543
35	1	0.1443	35	1	0.1539	35	1	0.1635
36	1	0.1527	36	1	0.1629	36	1	0.1730
37	1	0.1613	37	1	0.1720	37	1	0.1827
38	1	0.1701	38	1	0.1815	38	1	0.1927
39	1	0.1792	39	1	0.1911	39	1	0.2030
40	1	0.1885	40	1	0.2011	40	1	0.2136
41	1	0.1980	41	1	0.2112	41	1	0.2244
42	1	0.2078	42	1	0.2217	42	1	0.2355
43	1	0.2178	43	1	0.2324	43	1	0.2468
44	1	0.2281	44	1	0.2433	44	1	0.2584
45	1	0.2385	45	1	0.2545	45	1	0.2703
46	1	0.2493	46	1	0.2659	46	1	0.2825
47	1	0.2602	47	1	0.2776	47	1	0.2949
48	1	0.2714	48	1	0.2895	48	1	0.3076
49	1	0.2828	49	1	0.3017	49	1	0.3205
50	1	0.2945	50	1	0.3142	50	1	0.3337
51	1	0.3064	51	1	0.3269	51	1	0.3472
52	1	0.3185	52	1	0.3398	52	1	0.3610
53	1	0.3309	53	1	0.3530	53	1	0.3750
54	1	0.0435	54	1	0.3364	54	1	0.3364

APPENDIX 4 (Cont.)
VOLUME TABLES
FOR
BALSA LOGS
(Lengths in metres. Diameters in centimeters)

BALSA VOLUME TABLES 1.8m length			BALSA VOLUME TABLES 2m length			BALSA VOLUME TABLES 2.2m length		
Diameter	Tally	Volume	Diameter	Tally	Volume	Diameter	Tally	Volume
17	1	0.0409	17	1	0.0454	17	1	0.0499
18	1	0.0458	18	1	0.0509	18	1	0.0560
19	1	0.0510	19	1	0.0567	19	1	0.0624
20	1	0.0565	20	1	0.0628	20	1	0.0691
21	1	0.0623	21	1	0.0693	21	1	0.0762
22	1	0.0684	22	1	0.0760	22	1	0.0836
23	1	0.0748	23	1	0.0831	23	1	0.0914
24	1	0.0814	24	1	0.0905	24	1	0.0995
25	1	0.0884	25	1	0.0982	25	1	0.1080
26	1	0.0956	26	1	0.1062	26	1	0.1168
27	1	0.1031	27	1	0.1145	27	1	0.1268
28	1	0.1108	28	1	0.1232	28	1	0.1260
29	1	0.1189	29	1	0.1321	29	1	0.1355
30	1	0.1272	30	1	0.1414	30	1	0.1453
31	1	0.1359	31	1	0.1510	31	1	0.1555
32	1	0.1448	32	1	0.1608	32	1	0.1660
33	1	0.1540	33	1	0.1711	33	1	0.1769
34	1	0.1634	34	1	0.1816	34	1	0.1882
35	1	0.1732	35	1	0.1924	35	1	0.1997
36	1	0.1832	36	1	0.2036	36	1	0.2117
37	1	0.1935	37	1	0.2150	37	1	0.2239
38	1	0.2041	38	1	0.2268	38	1	0.2365
39	1	0.2150	39	1	0.2389	39	1	0.2495
40	1	0.2262	40	1	0.2513	40	1	0.2628
41	1	0.2376	41	1	0.2641	41	1	0.2765
42	1	0.2494	42	1	0.2771	42	1	0.2905
43	1	0.2614	43	1	0.2904	43	1	0.3048
44	1	0.2737	44	1	0.3041	44	1	0.3195
45	1	0.2863	45	1	0.3181	45	1	0.3345
46	1	0.2991	46	1	0.3324	46	1	0.3499
47	1	0.3123	47	1	0.3470	47	1	0.3656
48	1	0.3257	48	1	0.3619	48	1	0.3817
49	1	0.3394	49	1	0.3771	49	1	0.3981
50	1	0.3534	50	1	0.3927	50	1	0.4148
51	1	0.3677	51	1	0.4086	51	1	0.4320
52	1	0.3823	52	1	0.4247	52	1	0.4494
53	1	0.3971	53	1	0.4412	53	1	0.4854
54	1	0.4122	54	1	0.4580	54	1	0.5038

APPENDIX 4 (Cont.)
VOLUME TABLES
FOR
BALSA LOGS
(Lengths in metres. Diameters in centimeters)

BALSA VOLUME TABLES 2.4m length			BALSA VOLUME TABLES 2.6m length			BALSA VOLUME TABLES 2.8m length		
Diameter	Tally	Volume	Diameter	Tally	Volume	Diameter	Tally	Volume
17	1	0.0545	17	1	0.0590	17	1	0.0636
18	1	0.0611	18	1	0.0662	18	1	0.0713
19	1	0.0680	19	1	0.0737	19	1	0.0794
20	1	0.0754	20	1	0.0817	20	1	0.0880
21	1	0.0831	21	1	0.0901	21	1	0.0970
22	1	0.0912	22	1	0.0988	22	1	0.1064
23	1	0.0997	23	1	0.1080	23	1	0.1163
24	1	0.1086	24	1	0.1176	24	1	0.1267
25	1	0.1178	25	1	0.1276	25	1	0.1374
26	1	0.1274	26	1	0.1380	26	1	0.1487
27	1	0.1374	27	1	0.1489	27	1	0.1603
28	1	0.1478	28	1	0.1601	28	1	0.1724
29	1	0.1585	29	1	0.1717	29	1	0.1849
30	1	0.1696	30	1	0.1838	30	1	0.1979
31	1	0.1811	31	1	0.1962	31	1	0.2113
32	1	0.1930	32	1	0.2091	32	1	0.2252
33	1	0.2053	33	1	0.2224	33	1	0.2395
34	1	0.2179	34	1	0.2361	34	1	0.2542
35	1	0.2309	35	1	0.2501	35	1	0.2694
36	1	0.2443	36	1	0.2646	36	1	0.2850
37	1	0.2581	37	1	0.2796	37	1	0.2301
38	1	0.2722	38	1	0.2949	38	1	0.3176
39	1	0.2867	39	1	0.3106	39	1	0.3345
40	1	0.3016	40	1	0.3267	40	1	0.3519
41	1	0.3169	41	1	0.3433	41	1	0.3697
42	1	0.3325	42	1	0.3602	42	1	0.3879
43	1	0.3485	43	1	0.3776	43	1	0.4066
44	1	0.3649	44	1	0.3953	44	1	0.4257
45	1	0.3817	45	1	0.4135	45	1	0.4453
46	1	0.3989	46	1	0.4321	46	1	0.4653
47	1	0.4164	47	1	0.4511	47	1	0.4858
48	1	0.4343	48	1	0.4705	48	1	0.5067
49	1	0.4526	49	1	0.4903	49	1	0.5280
50	1	0.4712	50	1	0.5105	50	1	0.5498
51	1	0.4903	51	1	0.5311	51	1	0.5720
52	1	0.5097	52	1	0.5522	52	1	0.5946
53	1	0.5295	53	1	0.5736	53	1	0.6177
54	1	0.5497	54	1	0.5955	54	1	0.6413

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